ABET
Self-Study Report

for the

Chemical Engineering Program

at the

United States Military Academy

West Point, New York

July 1, 2020

CONFIDENTIAL

ABET SELF-STUDY REPORT FOR THE CHEMICAL ENGINEERING PROGRAM AT THE UNITED STATES MILITARY ACADEMY

TABLE OF CONTENTS

BACKGROUND INFORMATION i

CRITERION 1. STUDENTS 1-1

CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES 2-1

CRITERION 3. STUDENT OUTCOMES 3-1

CRITERION 4. CONTINUOUS IMPROVEMENT 4-1

CRITERION 5. CURRICULUM 5-1

CRITERION 6. FACULTY 6-1

CRITERION 7. FACILITIES 7-1

CRITERION 8. INSTITUTIONAL SUPPORT 8-1

PROGRAM CRITERIA PC-1

ACCREDITATION POLICIES AND PROCEDURES MANUAL APPM-1

Appendix A. Course Syllabi A-1

Appendix B. Faculty Resumes B-1

Appendix C. Equipment C-1

Appendix D. Institutional Summary D-1

BACKGROUND INFORMATION

A. Contact Information
[Page ii] List name, mailing address, telephone number, fax number, and e-mail address for the primary pre-visit contact person for the program.

B. Program History
[Page ii] Include the year implemented and the date of the last general review. Summarize major program changes with an emphasis on changes occurring since the last general review.

C. Options
[Pages ii to iii] List and describe any options, tracks, concentrations, etc. included in the program.

D. Program Delivery Modes
[Page iii] Describe the delivery modes used by this program, e.g., days, evenings, weekends, cooperative education, traditional lecture/laboratory, off-campus, distance education, web-based, etc.

E. Program Locations
[Page iii] Include all locations where the program or a portion of the program is regularly offered (this would also include dual degrees, international partnerships, etc.).

F. Public Disclosure
[Page iii] Provide information concerning all the places where the Program Education Objectives (PEOs), Student Outcomes (SOs), annual student enrollment and graduation data is posted or made accessible to the public. If this information is posted to the Web, please provide the URLs.

G. Deficiencies, Weaknesses or Concerns from Previous Evaluation(s) and the Actions Taken to Address Them
[Page iii] Summarize the Deficiencies, Weaknesses, and/or Concerns remaining from the most recent ABET Final Statement. Describe the actions taken to address them, including effective dates of actions, if applicable. If this is an initial accreditation, it should be so indicated.

[Red font page numbers added by USMA Chemical Engineering.]

Note: The section headings are hyperlinked within this document. The reader can return to this location by holding down the Alt key and pressing the left arrow [Alt] – [←].

A. Contact Information

LTC Matthew Armstrong
Chemical Engineering Program Director
Department of Chemistry and Life Science
Building 753 Bartlett Hall
West Point, NY 10996
Phone: 845-938-8555
Fax: 845-938-2235
Email: matthew.armstrong@westpoint.edu

B. Program History

- Program inception: Fall of Term 2002 (AY03-1), first students select major.
- First Graduating Class: Spring Term of 2005 (AY05-2) May 28, 2005.
- Engineering electives offered beginning in the fall 2010 (AY11-1 and AY11-2). Effective for the Class of 2011.
- CH485 Heat & Mass Transfer offered Fall Term of 2009 (AY11-1). Effective for the Class of 2010.
- CH400 Chemical Engineering Professional Practice offered in the Spring Term of 2010 (AY10-2). Effective for the Class of 2010.
- Program Educational Objectives revised 2009-2011.
- Credit hours increased in CH400 from 1.0 to 1.5 Spring Term 2014 (AY14), effective for the Class of 2014.
- First ABET visit: Fall Term of 2014 (AY15). The program received initial accreditation backdated to 1 October 2012. (The PEV felt criteria were satisfied much earlier than this, but this date was the earliest allowed by ABET Policies and Procedures.)
- CH365 Chemical Engineering Thermodynamics approved Fall 2012 and to be offered in the Fall Term of 2016 (AY17), effective for the Class of 2017.
- CH367 Automatic Process Control approved Fall of 2016 and offered Spring Term of 2019 (AY19), effective for the Class of 2020.
- Second ABET visit: Fall Term of 2020 (AY21).

C. Options

- *Chemical Engineering*. A detailed description of the curriculum is found in Criterion 5.
- *Chemical Engineering with Honors*. This is essentially the same curriculum as chemical engineering, but students must complete one semester of independent study beyond program requirements and must maintain a grade point average of 3.5 in the major courses.

- *Chemical Engineering Studies.* This program is not seeking accreditation. Chemical Engineering Studies is a 40-course fallback major with a less-rigid prerequisite structure that is designed to allow students to graduate on time if they should fail a chemical engineering course.

D. Program Delivery Modes

The chemical engineering program is offered in the traditional classroom lecture and laboratory format, consisting of face-to-face meetings between instructors and all students enrolled in a course. All students live and attend class on-campus. Some students spend one semester away from West Point as part of a semester exchange program with foreign universities or with the other federal service academies (United States Naval Academy, United States Air Force Academy, or United States Coast Guard Academy). On a case-by-case basis, a student may study via distance education if a required course is not offered at the exchange institution, the term in which the course is taken is critical to the prerequisite structure of the student's course sequence. Distance learning is also contingent on the department's ability to support individual cadets studying via distance learning. The distance learning experience is structurally identical to the local version of the course, with students following the same syllabus, completing identical problem sets and examinations, and interacting with the instructor via email.

E. Program Locations

The program is offered in classrooms and laboratories located at the United States Military Academy, West Point, NY 10996. There are no dual degrees or international partnerships.

F. Public Disclosure

The Program Educational Objectives (PEOs) and the Student Outcomes (SOs) for the chemical engineering program at the United States Military Academy are published in the Academy's Redbook at https://courses.westpoint.edu/static/index.htm in Part 2: Disciplinary Offerings.

The PEOs and SOs are also available at https://www.westpoint.edu/ by clicking "Explore Academic Program," then "Majors and Minors on the left side of the web page, and then clicking "Chemical Engineering." Annual student enrollment and graduation data is also posted in this last link.

G. Deficiencies, Weaknesses or Concerns from Previous Evaluation(s) and the Actions Taken to Address Them

There were no deficiencies, weaknesses or concerns from the previous evaluation and therefore there were no actions taken to address them.

CRITERION 1. STUDENTS

A. Student Admissions
[Pages 1-2 to 1-5] Summarize the requirements and process for accepting new students into the program.

B. Evaluating_Student_Performance
[Pages 1-5 to 1-8] Summarize the process by which student performance is evaluated and student progress is monitored. Include information on how the program ensures and documents that students are meeting prerequisites and how it handles the situation when a prerequisite has not been met.

C. Transfer Students and Transfer Courses
[Page 1-8] Summarize the requirements and process for accepting transfer students and transfer credit. Include any state-mandated articulation requirements that impact the program.

D. Advising and Career Guidance
[Pages 1-8 to 1-11] Summarize the process for advising and providing career guidance to students. Include information on how often students are advised, who provides the advising (program faculty, departmental, college or university advisor).

E. Work in Lieu of Courses
[Page 1-11] Summarize the requirements and process for awarding credit for work in lieu of courses. This could include such things as life experience, Advanced Placement, dual enrollment, test out, military experience, etc.

F. Graduation Requirements
[Page 1-12] Summarize the graduation requirements for the program and the process for ensuring and documenting that each graduate completes all graduation requirements for the program. State the name of the degree awarded (Master of Science in Safety Sciences, Bachelor of Technology, Bachelor of Science in Computer Science, Bachelor of Science in Electrical Engineering, etc.)

G. Transcripts of Recent Graduates
[Page 1-13] The program will provide transcripts from some of the most recent graduates to the visiting team along with any needed explanation of how the transcripts are to be interpreted. **These transcripts will be requested separately by the team chair.** State how the program and any program options are designated on the transcript. (See 2014-2015 APPM, Section II.G.4.a.)

[Red font page numbers added by USMA Chemical Engineering]

A. Student Admissions

The Academy does not admit students directly to the engineering programs. Any student admitted to the school can choose an engineering major if they are in good academic standing. So, the paragraphs that follow below describe the process for accepting students into the school, followed by a description of how the students choose their majors. The administrative details of the admissions process are described and available to the general public on the USMA admissions web page (https://westpoint.edu/admissions). The entire process is also conveniently described in the *Steps to Admission*, found at https://westpoint.edu/admissions/steps-to-admission.

Each year the United States Military Academy enrolls about 1,150 to 1,200 students, and these students become the newest members of the cadet corps. They come from all corners of the United States as well as several foreign countries, and they represent nearly every race, religion, and culture. This diversity helps cadets gain a cultural as well as a rich educational experience. Prospective cadets must meet the requirements specified by public law and must be qualified academically, physically, and medically. Prior to enrollment, students follow an admissions process that includes opening an admissions file, completing a questionnaire, obtaining a nomination, and passing a physical exam. Candidates are then carefully screened by an admissions committee before an offer of admission is made.

A unique feature of the West Point admission process is the nomination. Each candidate must obtain a congressional or service-connected nomination. A nomination is the legal authority for the U.S. Military Academy to consider a candidate for admission. Students are advised on the website to apply for a nomination when they complete the Candidate Questionnaire to open their admission file. Every U.S. citizen has at least four legal nominating sources: two U.S. senators, a member in the U.S. House of Representatives and the Vice President. Each of these has its own application forms, so candidates must go to the applicable members' websites, and links to the offices are found in the Steps to Admission. Nominating officials have different times that they accept nomination requests, so candidates are encouraged to contact officials as early as possible. Normally this is initiated in the junior year in high school. There are also other types of nominations connected with military service, such as active duty soldiers, presidential nominations, sons and daughters of deceased veterans, sons and daughters of recipients of the Congressional Medal of Honor, Regular Army and Army Reserve, and high school ROTC programs. International students may also apply. The procedure is similar for them, although they must be sponsored by an official of an invited national-level government. Each of these categories is described in the Steps to Admission and additional guidance is given on the web site.

After the nomination is complete, the candidate is further evaluated based on physical and medical criteria. The physical fitness qualification is determined by performance on the Candidate Fitness Assessment (CFA). The CFA consists of six events: a modified basketball throw from a kneeling position, cadence pull-ups (or flexed-arm hang for females who cannot perform pull-ups), timed 40-yard agility run, two minutes of abdominal crunches, two minutes of push-ups, and a timed one-mile run. To prepare for the CFA, candidates are recommended to reach the level of physical conditioning required for participation in a strenuous team sport. The CFA is administered by a designated Army officer at an Army facility near the candidate. Candidates must pass the CFA to qualify for admission to the Academy.

The next step in the application process is a qualifying medical examination. Candidates receive instructions for taking the examination directly from either the Department of Defense

Medical Examination Review Board (DoDMERB) or their civilian contractor at the appropriate time, and the examination is administered at a facility near the candidate's home. Although medical standards differ among the various commissioning programs of the Armed Services (notably vision standards), only one medical examination is needed to meet the application requirements of all service academies and the four-year ROTC scholarship programs. Upon review of the completed medical examination, DoDMERB notifies the candidate of the results.

The candidates are then reviewed by the Admissions Committee. West Point seeks a class composition of top scholars, leaders, and athletes. The committee evaluates qualified candidates on academic performance (high school record and SAT or ACT scores), demonstrated leadership potential, physical aptitude, and medical qualification. In addition, candidates must be between 17 and 23 years of age at the time of matriculation, and not be married, pregnant, or legally responsible for a child. To maintain a diverse collegiate environment and student body, class composition goals are established that are consistent with guidance from Department of the Army and in recognition of the demographics of the college-bound high school population. Candidates with outstanding qualifications in one or more areas and those who have extenuating social, financial, or family circumstances that limit athletic, academic, or leadership opportunities may receive special consideration for admission. The Academy has a rolling admissions policy. Outstanding, qualified, nominated candidates will be offered admission as their records become complete. All admissions files must be complete, to include nominations, by the last workday in February. Ultimately, the admissions process recruits and screens approximately 12,000 applicants per year, of whom about 4000 receive nominations, and 2200 will be determined to be fully qualified. The Academy offers admission to approximately 1600 candidates, of which about 1200 will enter the class. Some of the characteristics our students are described by the data shown in the profile data on the following two pages.

Standardized test scores of entering classes for the past six years (as of Dec 2019):

Academic Year	**Composite ACT**		**Composite SAT**		**Percentile Rank in High School**		**Number of New Students Enrolled**
	MIN	**MEAN**	**MIN**	**MEAN**	**MIN**	**MEAN**	
14-15	20	25	820	1255	9	84	1224
15-16	19	26	810	1261	3	84	1167
16-17	17	28	910	1257	3	83	1173
17-18	16	28	900	1262	9	85	1198
18-19	16	28	800	1260	7	84	1243
19-20	18	28	880	1250	7	84	1266

Profile of the entering class of 2023:

Volume of Applicants	**Men**	**Women**	**Total**
Applicant Files Started	8562	3113	11,675
Nominated	2954	941	3895
Qualified (academically and physically)	1631	491	2122
Admitted	920	281	1201
SAT Average			1286
ACT Average			30
Class valedictorians			89
Class presidents			135
Team captains			792
Varsity letters			1032

Rank in High School Class§	Percentage of Incoming Class
First Fifth	71
Second Fifth	19
Third Fifth	8
Fourth Fifth	2
Bottom Fifth	0

College Board Scholastic Assessment Test (SAT) Range§	Critical Reading	Math
700-800	25	25
600-699	41	41
500-599	30	30
400-499	3	3
300-399	0	0
Mean	634	653

Academic Honors§	Number Recognized
Class Valedictorians	72
Class Salutatorians	34
National Merit Scholarship Recognition	525
National Honor Society	698

§ Most recent data published online at https://www.westpoint.edu/admissions/class-profile and last updated on 6 July 2018.

Distribution of all cadets in attendance during Academic Year 2019-2020* as follows:

Graduation year	# Cadets	# Males	# Females	% Males	% Females
2020	1222	960	262	79	21
2021	1204	917	287	76	24
2022	1210	918	292	76	24
2023	1201	920	281	77	23

Distribution of all cadets in attendance during Academic Year 2019-2020* by ethnicity:

Grad Year	Total	American Indian	Asian	Black	Caucasian	Hispanic	Pacific Islander	Other	Unknown
2020	1222	13	121	196	851	117	**	32	2
2021	1204	15	107	214	777	121	**	23	0
2022	1210	11	96	183	806	102	**	12	0
2023	1201	17	97	180	858	149*	10	27	0

* Snapshot of each class as of 1st day of academic classes; ** Not tracked

As mentioned above, no students are admitted directly to engineering programs. Cadets select a major during the Spring Term of their Freshman Year, and engineering classes begin during the Spring Term of their Sophomore Year. Cadets may choose from any major offered at the Academy. Except for Kinesiology, there are no enrollment limits or minimum standards (other than being in good academic standing) for the majors. Any cadet may elect to major in an engineering discipline. Cadets make this important choice after consultation with faculty who serve as Company Academic Counselors (CACs) and Department Academic Counselors (DACs). Briefings, websites, and department open houses provide opportunities for cadets to learn about the majors available. After selecting a major, the cadet meets with a DAC to develop an 8-Term Academic Program (8TAP) that identifies all courses needed to complete the major and graduate at the end of the 47-month West Point experience.

B. Evaluating Student Performance

The policies and procedures presented here are documented in Part I of the Academy's Redbook (Course Catalog). The Redbook can be found by the general public on the Academy's external web page (https://westpoint.edu/academics/curriculum). The course catalog for a specific graduation year (GY) can be found here. Specifics can also be found in our Dean's Policy and Operating Memorandum 02-1 (DPOM 02-1, Grade Keeping), which is available on request.

Student performance is evaluated at the course level and progress is monitored at the department-, program-, and course-level. The general philosophy is that students are evaluated based on their numerical scores on graded events, such as exams, quizzes, homework, lab exercises, computer problems, and reports. Grades are not curved. Instead, we establish reasonable standards of achievement in advance, present these to the students, and grade them based on their ability to meet the standards. Once standards are established, the principal responsibility for academic performance rests with the individual student. Every course has a set of graded activities on which students must achieve satisfactory performance.

Instructors generally use two types of major examinations to monitor student progress: The *Written Partial Review (WPR)* is similar to a mid-term exam and is designed to test knowledge of course material covering specified lessons. The program and instructor determine the material to be covered, the time of the examination, and the weight of the examination. WPRs are scheduled during normal class time, Dean's Hour (hour after lunch, approximately every other day), or Study Days (every other week). The *Term-End Examination (TEE)* is the final exam, and tests cadets' knowledge of course material presented during that term. Other graded course requirements include, but are not limited to quizzes, design reports, laboratory reports, portfolios, and computer exercises. The *course director* is responsible for assigning the relative weight of the graded course requirements in terms of points. The instructor provides the list of course requirements and their weights to the students enrolled in his or her course prior to the start of the course.

Instructors are responsible for providing sound instruction, measuring student performance with graded events, and providing timely feedback to the students concerning the quality of their work. To indicate their performance during the course, instructors provide numerical scores from the graded events to the students. These numerical scores are based on various grading schemes, cut scales and rubrics that instructors use to assess student performance. The students can easily convert these scores to a letter grade using published grade scales and should understand how to do this for each of their courses within the first few lessons of each term. The grade scale ranges from A+ to F, and a typical percentage equivalence scale is shown below. Chemical engineering cadets are provided with this scale in the *Standing Instructions for Students (SIS)* document that accompanies each course. The exact scale will vary somewhat from course to course. The assignment of letter grades occurs at the end of the course after the TEE is complete and after the grades are reviewed by the program director and the department head.

Letter Grade	Numerical Score	Letter Grade	Numerical Score	Letter Grade	Numerical Score	Letter Grade	Numerical Score
A+	97%	B+	87%	C+	77%	D	67%
A	93%	B	83%	C	73%	F	<67%
A-	90%	B-	80%	C-	70%		

Students monitor their grades through the Cadet Information System. This system is secure and protected by the use of a password connected to the Common Access Card (CAC), which is a chip-embedded identification card received upon arrival at West Point. After logging on, students can view their current numerical course averages, as well as grades on individual graded events. Course directors must upload grades at least four times during a semester (after the sixth, tenth, and fifteenth weeks of the term and the final grade). In accordance with the Privacy Act, grades are confidential, and students must give written permission for the Academy to send academic reports to parents or guardians.

Quality points are used to compute the students' Academic Performance Score (APS) and Quality Point Average (QPA). Quality points associated with letter course grades are listed in the table below:

Letter Grade	Quality Points	Letter Grade	Quality Points	Letter Grade	Quality Points	Letter Grade	Quality Points
A+	4.33	B+	3.33	C+	2.33	D	1.00
A	4.00	B	3.00	C	2.00	F	0.00
A-	3.67	B-	2.67	C-	1.67		

The APS is based on grades in all courses taken, excluding Military Science and Physical Education. The APS for the most recent term is designated as the APST, and the cumulative score is the APSC. In the APSC, grades in repeated courses replace prior grades of "D" and "F." The following table presents the minimally acceptable APS standards. Cadets with averages below those stated are considered deficient and are considered for separation by the Academic Board.

CLASS YEAR	TERM	APST	APSC
Freshman	First Term	1.67	N/A
	Second Term	1.67	1.70
	STAP*	N/A	1.70
Sophomore	First Term	1.67	1.80
	Second Term	1.67	1.90
	STAP*	N/A	1.90
Junior	First Term	1.67	1.95
	Second Term	1.67	1.95
	STAP*	N/A	1.95
Senior	First Term	1.67	2.00
	Second Term	1.67	2.00
	STAP*	N/A	2.00

*STAP = Summer Term Academic Program

The Quality Point Average (QPA) is based on grades in all academic, military science, and physical education courses. It roughly corresponds to the grade point average (GPA) used in other colleges and universities. The TQPA is based on grades in all courses taken during a semester, and the Cumulative Quality Point Average (CQPA) is based on grades in all courses previously taken at the Academy, with repeated courses replacing prior grades of "D" and "F." In addition to passing each required course, cadets must achieve a minimum CQPA of 2.00 to graduate. Graduation requirements are discussed in more detail below.

When a student fails a course, the USMA Academic Board meets to review the cadet's record and to decide the disposition of the student. The board's options are to recommend the cadet retake the course (either during the Summer Term Academic Program (STAP) or in a future academic term), keep an unresolved failure in his/her academic record (only allowed if course is not required for graduation) or be separated from the Academy. If a cadet has to retake a course the following semester, they might be "turned back," which means they are required to spend a fifth year at the Academy. Because the requirements for the chemical engineering major are more stringent than the general USMA graduation requirements, a cadet who fails a class may be dropped from the chemical engineering major and revert to a different non-ABET-accredited major (Chemical Engineering Studies) requiring fewer courses to complete.

Early identification of academic distress is critical to proper remediation. This means that the faculty members are heavily involved in monitoring student grades and performance. Prior to selection of the major, students are monitored by the Company Academic Counselors (CACs). Once the student has chosen a major, student progress toward completion of the major is monitored by the Department Academic Counselors (DACs). The CACs and DACs are USMA department faculty members. The CACs can be from any department or program, and are assigned by the academic departments, usually one per company. The DACs are faculty in the program in which the student is majoring. Once a student chooses the chemical engineering major, the program assigns the cadet to a DAC. The DACs then monitor their students' performance in their chemical engineering and other classes. When a student is experiencing academic difficulties, the DAC counsels the student on methods to improve performance and, if necessary, modifies the student's academic plan (such as changing from the chemical engineering major to another major).

The program DACs carefully monitor compliance with prerequisites in order to ensure proper advancement through the chemical engineering program and to ensure that students have the correct background for the courses. Prerequisites for each course are listed in the Redbook (course catalog). The Redbook is updated annually and program directors are responsible for ensuring that course descriptions and prerequisites are correct. When students pick the chemical engineering major, the DAC enters the choice into the Academy Management System (AMS) and the required courses are automatically placed into the students' 8-Term Academic Plan (8TAP). The courses are also automatically placed in the correct sequence. The DACs then meet with the cadets to perform term-to-term load balancing, to help the cadet customize their schedule, and to choose electives.

Any changes that are made that result in prerequisite violations are flagged by the AMS system, and that student cannot graduate until the conflict is resolved. The students' academic counselors are responsible for monitoring the student record for prerequisite violations, and to thoroughly review the students' record for such violations at least once a year. Prerequisite waiver may be granted by counselors only with permission of the program director, and a complete description of the waiver and the reasons for granting it must be placed in the students' department academic file.

When a prerequisite violation has been detected in the AMS system, it means that the courses are taken out of sequence or that the prerequisite course has not been taken. The violation must be repaired, or the student could be denied a chemical engineering degree and be required to switch to a non-ABET-accredited major. Switching to a non-accredited major helps to ensure that the student will still graduate on time. Since the chemical engineering major has more courses (42.5 versus 40 minimum for USMA), there is considerably less flexibility in the sequencing of the courses. If the prerequisites are not met or not met in the proper sequence, a student could theoretically be held back at USMA for an additional semester or year.

C. Transfer Students and Transfer Courses

Because of the unique requirements of West Point, all students, regardless of previous college experience, must enroll as freshmen. Consequently, the Academy has no transfer students.

Transfer credit is not awarded for courses taken at other institutions. The exception to the transfer policy is that the program can award transfer credit for program-approved courses cadets complete as part of the semester exchange program. These courses will have a "T" in place of a letter grade on their transcript. There is a policy for validating courses, described below. Validations are generally for core classes, although there have been instances in which a student seeks credit for an advanced course taken at another institution. These situations are handled separately on a case-by-case basis. The head of the department responsible for the USMA version of the course makes any approval of validation credit after consultation with the program director. The student must produce an official transcript from the institution and may be required to take an additional validation exam to confirm their degree of mastery of the material. The course would then be entered as a "validation" in the transcript.

D. Advising and Career Guidance

The Academic Affairs and Registrar Services (AARS), Office of the Dean, coordinates the faculty-based academic counseling programs available to students. Within the Counseling Branch, there are counselors available during normal working hours on a walk-in basis. They can discuss elective choices, schedules, course changes and overloads, and can make changes in a cadet's schedule. As mentioned earlier, Company Academic Counselors (CACs) advise cadets during freshmen year, before cadets have selected a major. Department Academic Counselors (DACs) advise cadets after they have chosen their majors. All of the counseling duties, responsibilities, and procedures are published for faculty use at the internal website (not accessible to PEVs) https://usarmywestpoint.sharepoint.com/sites/AARS/Lists/CounselingCornerLinks/AllItems.aspx Postings on this web site include the Academic Counseling Handbook, DAC notes from AARS briefings, DAC and CAC lists, and many other important documents to assist with counseling.

Once a student expresses an interest in becoming a chemical engineering major, the program assigns a DAC to the student. One faculty member (Program Director) has overall responsibility for assigning DACs to students to balance the advising load of all faculty members. Senior DACs within the program mentor all DACs in the advising process and update the program's DAC SOP (standard operating procedure) to assist junior DACs in potential scenarios outside the standard 8TAP. The Chemical Engineering DAC SOP is available upon request.

The DAC advises the student of the options within the chemical engineering major and explains the curriculum. Once a student selects the major and technical electives, the DAC updates the student's online 8TAP. Overall management of the 8TAP is at the Dean's level, as only the Registrar's office can enroll or move certain courses that can affect a cadet's overall schedule. The requirements for graduation outlined in the USMA Academic Program (Redbook), to include core course and major requirements, are built into software checks of the program. The DAC annotates discussions and changes made to the 8TAP, any waivers required, and upcoming requirements (if applicable) in the "Advisor Remarks" section of the online 8TAP. The 8TAP and remarks are visible to the cadets at all times in the online system. New for AY20, cadets also have the ability to change their own 8TAPs and course enrollment during specific times of a semester. DACs are still notified of any changes made to an 8TAP and will monitor 8TAPs for all necessary requirements.

Students continue with their assigned DAC during the remainder of their undergraduate education. If a student's DAC departs, the Head DAC assigns a new DAC to the student. DACs meet with their students each semester to review the 8TAP. The DAC approves any revisions or changes to the program (to include changes of electives), inputs these changes to the plan, prints and signs a new 8TAP, and places a copy in the student's files. Prior to approval of the desired changes, the DAC performs a graduation check with the AMS software package to ensure that graduation requirements are met and to identify and fix any violations in required courses or prerequisites.

As a final check that students meet all graduation requirements, individual DACs manually verify the student has satisfied all curriculum requirements (assuming successful completion of spring term).

The Head DAC has several other responsibilities to ensure all cadets meet required graduation requirements. These include:

- Updating chemical engineering major templates.
- Orienting new and returning faculty members for counseling duties.
- Training department academic counselors (DACs).
- Ensuring all chemical engineering majors meet graduation requirements. These checks are performed each year.
- Ensuring mandatory counseling is provided for cadets on academic probation (as provided by AARS).
- Facilitating schedules for chemical engineering majors who participate in the Academy Exchange Program or semester abroad program.
- Coordinating ADD/DROP in the week prior to each term.
- Coordinating the enrollment of cadets into department courses for which they have been waitlisted.
- Facilitating sign-up of freshmen as chemical engineering majors.
- Facilitating review of senior cadets' transcripts in the spring term to ensure all graduation requirements are met.

Early in their senior year, our students undergo branch selection. This is the process by which they select the branch of the Army in which they would like to serve. An Army officer's military branch has a significant influence on their career progression, and determines such things as career and promotion milestones, types of job assignments, and types of advanced schooling. Examples of Army branches are the Chemical Corps, the Corps of Engineers, Finance, Aviation, Logistics, Ordnance, and many others. The USMA Department of Military Instruction (DMI) has created a program for educating the cadets about wide array of Army branches, career choices and options.

The DMI's Branching Program is shown in Figure 1-1. The program includes the Talent Management Program, Branch Education and Mentorship Program, and the Branch Assignment Process. These programs work together to ensure cadets are assigned branches for which they are best qualified based on matching the Branch Commandant votes with Cadet preference, while considering cadet overall performance, talent strengths, and the unique talent needs of each branch. Ultimately, the purpose of these programs is to meet the needs of the Army in terms of talent distribution across the Army's basic branches.

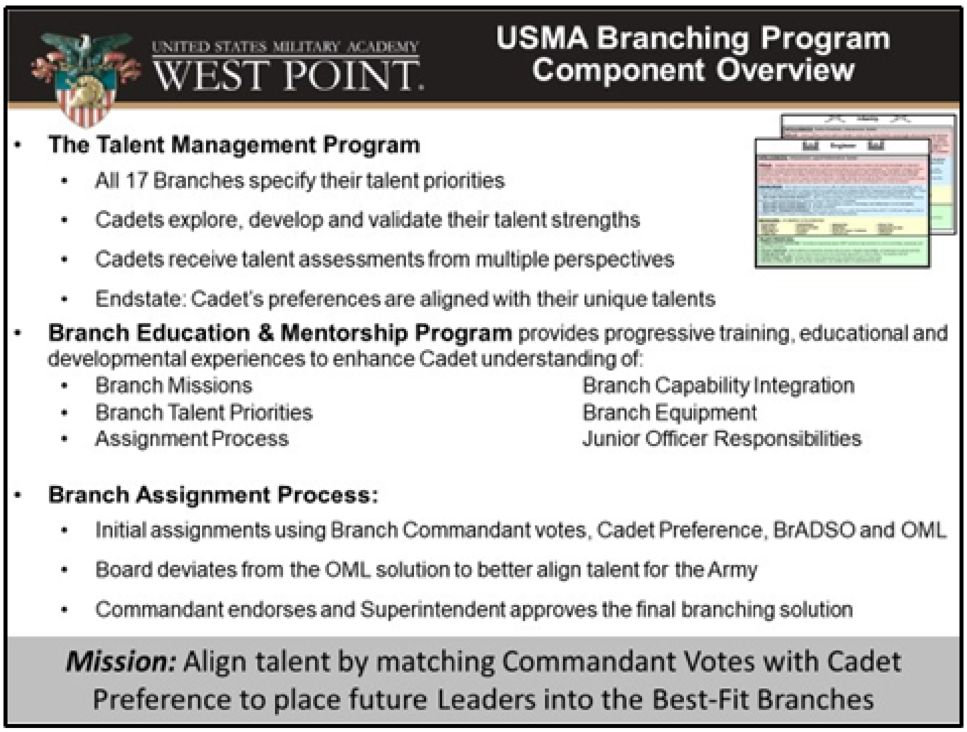


Figure 1-1. Overview of the USMA Branching Program.

Figure 1-2 shows the events, activities, and courses that provide career mentoring activities during the four-year experience. Cadets receive a significant amount of information in their military science courses. Branch mentorship is also provided through branch mentors, who are military faculty volunteers who represent their own branch and can provide details on career progression to the cadets. Cadets also receive briefings on branch selection during each of their four years. Other career counseling occurs during interactions with faculty inside and outside of the classroom, with club mentors and coaches, with tactical officers, and with their DACs. DACs also provide guidance and mentorship on civilian professional opportunities and graduate school opportunities.

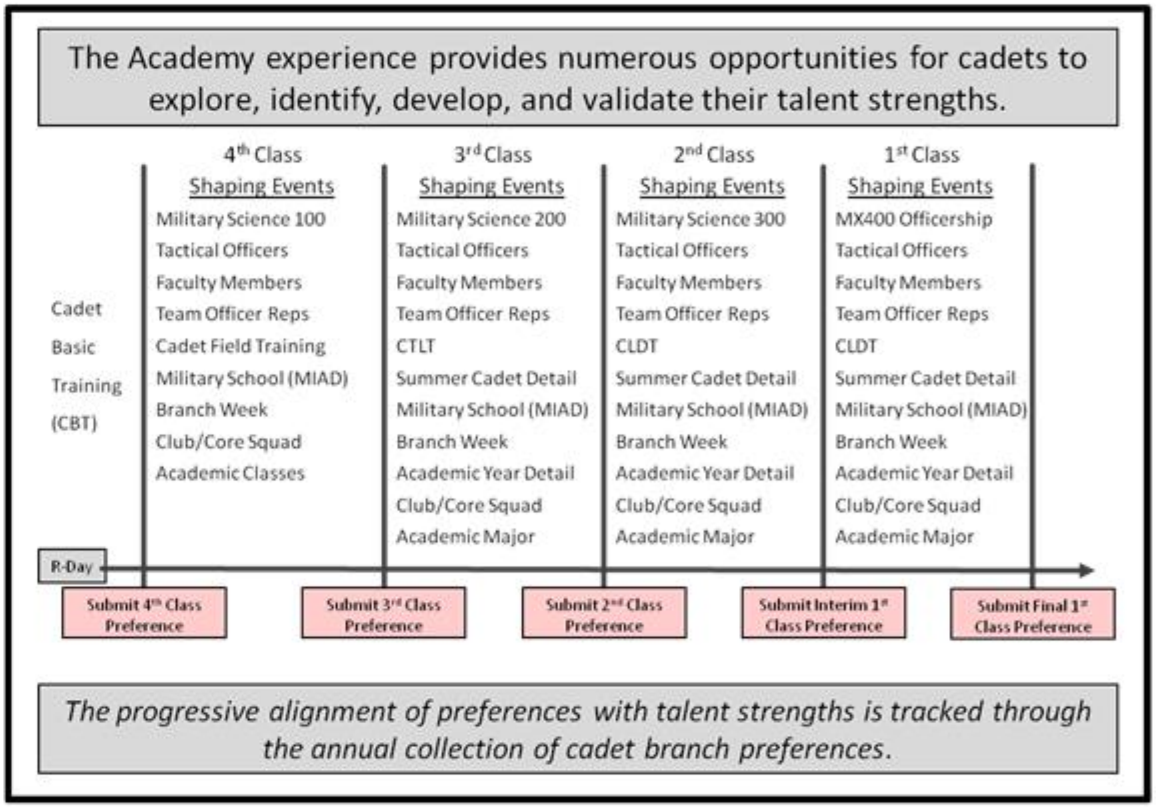


Figure 1-2. Career counseling events and activities during the 4-year cadet experience.

E. Work in Lieu of Courses

Cadets may be excused from (validate) certain core courses if they have sufficient knowledge of the subject to meet appropriate department’s standards. Credit earned in other colleges, Advanced Placement Examination scores, and tests administered at the Military Academy are considered in validation decisions. Advanced Placement Examination scores may be used in mathematics, physics, chemistry, history, social sciences, and foreign languages. Validation of core courses allows a cadet to substitute an additional elective in place of a core course. If a cadet shows unusual ability or has prior knowledge of the subject but does not validate the course, he may be enrolled in an advanced or accelerated version.

F. Graduation Requirements

Academy Regulations state that cadets of the First Class (seniors) who have been found by the Academic Board to have successfully completed the course of instruction, including academic, military, and physical education and training, who have maintained the standards of conduct, and who possess the moral qualities, traits of character and leadership essential for a graduated cadet, shall receive a diploma signed by the Superintendent, the Commandant of Cadets, and the Dean of the Academic Board, and shall there upon become a graduate of the United States Military Academy with a degree of Bachelor of Science. There are specific institutional and academic requirements. The institutional (nonacademic) requirements are the cadets must:

- Achieve a minimum CQPA of 2.00,
- Successfully complete a Military, Physical or Academic Individual Advanced Development (MIAD, PIAD, or AIAD) experience,

- Meet the height/weight standards of Army Regulation 600-9, and
- Meet the physical fitness standards in paragraph 1-24 of Army Regulation 350-1 and Appendix A of Army Training Circular 3-22.20.

To satisfy the graduation requirements, cadets must also:

- Successfully complete or validate each course in the core curriculum, including the common core courses and a core engineering sequence equivalent,
- Satisfy the requirements of at least one major,
- Successfully complete 40 academic courses, all required military science and development courses, and the physical education program managed by the Office of the Commandant,
- Achieve an Academic Program Score Cumulative (APSC) of at least 2.00.
- Achieve at least a 2.00 Cumulative Quality Point Average (CQPA).

The CQPA is an index of cumulative performance in all academic, military science, and physical education courses. It generally corresponds to grade point average (GPA) or grade point ratio (GPR) in other colleges and universities. As part of the West Point experience, a cadet is required to complete requirements and achieve minimum standards in three developmental programs within the West Point Leader Development System (WPLDS). Within the WPLDS the military program score (MPS), the physical program score (PPS), and the academic program score (APS) combine to form the cadet performance score (CPS). The APS is based on performance in courses within the Academic Program and does not include military science and physical education courses. Cadets who are deficient in one or more of the three developmental programs for failure to maintain minimum program performance standards may be considered by the Academic Board for separation.

The program also offers an honors option. For the Chemical Engineering with Honors major, students must:

- Satisfy the requirements for the chemical engineering major.
- Achieve a CQPA of at least 3.0 in the 26 common core courses.
- Achieve a CQPA of at least 3.5 in the courses taken as part of the major.
- Complete a 1-semester 3-credit independent study design or research project.

As described in sections B and D above, course deviations are handled to ensure that graduation requirements are met through DAC counseling and monitoring through the AMS system. Details are provided in those sections.

G. Transcripts of Recent Graduates

Transcripts from the most recent graduates will be provided to the team chair prior to the visit. The transcripts indicate that the student has received either a Bachelor of Science degree in Chemical Engineering or Chemical Engineering with Honors.

CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES

A. Mission Statement
[Page 2-2] Provide the institutional mission statement.

B. Program Educational Objectives
[Page 2-2] List the program educational objectives and state where they may be found by the general public as required by APPM Section I.A.6.a.

C. Consistency of the Program Educational Objectives with the Mission of the Institution
[Pages 2-2 to 2-5] Describe how the program educational objectives are consistent with the mission of the institution.

D. Program Constituencies
[Page 2-5 to page 2-23] List the program constituencies. Describe how the program educational objectives meet the needs of these constituencies.

E. Process for Review of the Program Educational Objectives
[Page 2-23 to page 2-26] Describe the process that periodically reviews the program educational objectives including how the program's various constituencies are involved in this process. Describe how this process is systematically utilized to ensure that the program's educational objectives remain consistent with the institutional mission, the program constituents' needs and these Criteria.

[Red font page numbers added by USMA Chemical Engineering]

A. Mission Statement

The mission of the United States Military Academy (USMA) is "to educate, train, and inspire the Corps of Cadets so that each graduate is a commissioned leader of character committed to the values of Duty, Honor, and Country and prepared for a career of professional excellence and service to the Nation as an officer in the United States Army." The mission statement can be found at https://westpoint.edu/.

B. Program Educational Objectives (PEOs)

During a career as commissioned officers in the United States Army and beyond, program graduates:

- Demonstrate effective leadership and chemical engineering expertise.
- Contribute to the solution of infrastructure or operational problems in a complex operational environment.
- Succeed in graduate school or other advanced study programs.
- Advance their careers through clear and precise technical communication.

The Program Educational Objectives (PEOs) and the Student Outcomes (SOs) for the chemical engineering program at the United States Military Academy are published in the Academy's Redbook at https://courses.westpoint.edu/static/index.htm in Part 2: Disciplinary Offerings. The PEOs are also available at https://www.westpoint.edu/ by clicking "Explore Academic Program," then "Majors and Minors on the left side of the web page, and then clicking "Chemical Engineering."

C. Consistency of the PEOs with the Mission of the Institution.

Alignment of Post-Graduation Timeline and PEOs.

ABET defines program educational objectives to be broad statements that describe what graduates are expected to attain within a few years of graduation. The preface to our PEOs states that "During a career as commissioned officers in the United States Army and beyond, program graduates…" It is clear from the wording of the preface statement and from the data shown later in this section of the self-study that our program clearly understands the intent of the definition. However, because of the unique nature of our institution, we are inclusive of graduates who remain in the military until retirement and those leave to enter the civilian workforce. The earliest a graduate can normally leave is after five years, and as a result, we consider the window for achievement of PEOs to be somewhat broader than the few years specified by ABET.

It is very clear that our PEOs target a post-graduation timeline. The phrase "as commissioned officers" means that the earliest point of time that the PEOs could theoretically refer to is graduation day since that is the day cadets are commissioned. Commissioned officers cannot be students at West Point. Moving forward on a timeline after graduation, all graduates take the Basic Officer Leadership Course (BOLC), which is branch-specific (it is different for say Corps of Engineers officers and Chemical Corps officers or Aviators). BOLC starts about 2 months after graduation and lasts 4-6 months depending on the branch. Cadet branch selection is now somewhat dependent on academic major (a recent change to the branch selection process). That is, the Army branches have identified desirable skill sets that are unique to their branches (see page 2-19). Therefore, BOLC is the first place where graduates can apply problem solving skills that they learn in their academic programs at USMA. BOLC is also one of the advanced study programs referred to in PEO3.

The “beyond” word in the PEO preface implies five years, since that is when our graduates begin to leave the army (statistically, about 10-50% leave the service after 5 five years). That is also when we expect former army officers to apply for civilian chemical engineering jobs. Our graduates are very competitive for these jobs, especially in the federal civilian workforce, since all federal positions give hiring preferences to former service men and women. So, by approximately year seven after graduation, those who leave the Army should (hopefully) be employed as chemical engineers or in some other career that uses the broad skill set, and they should have used those skills on the job. Those who stay in the Army after five years are increasingly doing more discipline-specific assignments by that point in their career, and we have a considerable amount of data to support this claim (pages 2-26 to 2-32). It is also clear from our review of Army documentation that the requirement for attaining PEOs within a few years is clearly understood, although broadened due to the special nature of our mission. This data and documentation are discussed thoroughly in the following sections.

Alignment of Academy Mission and PEOs.

The document “Educating Army Leaders” (EAL) helps to illustrate the connections between the academy mission and the chemical engineering PEOs. This document can be found on the USMA external web site referenced above (https://westpoint.edu), by clicking “Explore Academic Program,” then “Academic Leadership,” then “Academic Curriculum” on the right side of the page. EAL is near the bottom of the page. EAL explains how USMA achieves its educational mission. The academic component of the mission is addressed by specific statements of what our graduates can do, our “Academic Program Goals (APGs). There are the 7 intellectual domain goals and the overarching goal, explained on pages 7-12 of the EAL document and also listed in Table 2-1.

Table 2-1 shows a comparison of the USMA APGs and the chemical engineering PEOs. Chemical engineering program objectives are listed along the top of the table. The seven APGs are listed as items one to seven and the overarching goal is at the bottom. Each objective with significant overlap with an APG is designated with one or more bullets (•) in the table. The table illustrates significant alignment between the PEOs and the APGs. Since the APGs have been designed to support the academy mission, and there is significant overlap between the PEOs and the APGs, we conclude that the PEOs are fully consistent with the academy mission.

As shown in Table 2-1, the most significant overlap occurs between the overarching goal, as well as thinking critically and creatively (APG 2), ability to apply science, technology, engineering, and mathematics concepts and processes to solve complex problems (APG 5), and the ability to integrate and apply knowledge and methodological approaches gained through in-depth study of an academic discipline (APG 7). Other areas where there is a direct one-to-one correlation are in communication (APG 1), pursuing continued intellectual development (APG 3) and recognizing and applying ethical perspectives (APG 4). The ability to apply concepts from the humanities and social sciences (APG 6) overlaps with PEOs 2 and 4. The ability to apply these concepts is important for the development of engineering solutions, particularly in a complex operational environment. Also, communication skills learned in the humanities and social sciences lay an important foundation for effective technical writing.

Table 2-1. Mapping of Academic Program Goals to Program Educational Objectives.

(● designates alignment)	Chemical Engineering Program Educational Objectives			
	… leadership & chem. engineering expertise	… infrastructure and operational problems	… graduate school & advanced study progs.	… clear and precise tech. communication
↓ Academic Program Goal (APG)	1	2	3	4
1. Graduates communicate effectively with all audiences.				●
2. Graduates think critically and creatively.	●	●	●	
3. Graduates demonstrate the capability and desire to pursue progressive and continued intellectual development.			●	
4. Graduates recognize the ethical issues and apply ethical perspectives and concepts in decision-making.	●			
5. Graduates apply science, technology, engineering, and mathematics concepts and processes to solve complex problems.	●	●	●	
6. Graduates apply concepts from the humanities and social sciences to understand and analyze the human condition.		●		●
7. Graduates integrate and apply knowledge and methodological approaches gained through in-depth study of an academic discipline.	●	●	●	
Overarching Goal: Graduates integrate knowledge and skills from a variety of disciplines to anticipate and respond appropriately to opportunities and challenges in a changing world.	●	●	●	●

The Academy overall engages in a process to periodically review and refresh the APGs to ensure that they continue to be relevant. The original "intellectual domain goals" were first developed more than sixteen years ago and published in the document "Educating Future Army Officers for a Changing World," found at https://westpoint.edu/academics/curriculum/program-goals. They were in use during the previous ABET review cycle. The revised APGs found in the EAL were approved by the Academic Board in April of 2013 and phased in over the last several years. They have been in use for most of the current ABET review cycle.

D. Program Constituencies

List of Program Constituencies

The Army. The Army is our primary constituency since all of our graduates become officers in the United States Army after graduation, commissioned at the rank of Second Lieutenant.

The Chemical Engineering Profession. Graduates of the United States Military Academy can leave the Army after five years of active duty service. At this point, graduates may enter the civilian work force as chemical engineers in private companies or government agencies. Officers leaving the Army after five years with an engineering background are highly sought after as entry-level plant engineers, where skills learned during active duty, particularly involving teamwork and leadership, are directly transferrable and highly valuable. The Army itself hires a significant number of civilian chemical engineers, and as our program continues to mature, our graduates will inevitably find increasing employment within Army agencies, where their combination of engineering and officer skills are highly advantageous.

The Cadets. The cadets in the program form another important constituency. This group of students includes all "plebe" (freshmen), "yearling" (sophomore), "cow" (junior), and "firstie" (senior) cadets who are currently majoring in chemical engineering.

The Faculty. The faculty are the primary means by which we impart our program to the cadets. As such, they are an important constituency for the chemical engineering program. Most of our faculty are also active-duty army officers, and therefore represent the Army constituency as well.

The Chemical Engineering Advisory Board represents both the Army and the Chemical Engineering Profession. The civilian component consists of practitioners and members of academia. The military component consists of retired and active duty officers as well as representatives of the U.S. Army Corps of Engineers and the Chemical Corps, and program alumni.

COL (Ret) Paul Dietrich
Former Manager ConocoPhillips Bayway Refinery, Chief of Essential Services, Chief of Oil Plans, and Oil and Gas Infrastructure Analyst, STRATOPS
3855 Victory Blvd,
Staten Island, NY 10314-6716
paul@the-dietrichs.com
(718) 698-8526

COL (Ret) Gregory Allen Ritch
Former Engineer Officer (+7 years enlisted) and Commander, 464the Chemical Brigade in Johnstown, Pennsylvania
253 East Crawford Ave
Connellsville, PA 15425
garitch@cvzoom.net
(724) 984-0607

COL (Ret) Dwight Springer
Former Chemical Officer and Dep. Dept. Head,
USMA, Chemistry and Life Science
5456 Loftsmoor CT
Keller, TX 76248-5029
dss5456@verizon.net
(817) 431-5331

COL (Ret) Vance P. (Phil) Visser
Former Commandant, US CBRN School
and Chief, Chemical Corps Regiment
2925 Thomas Smith Lane
Williamsburg, VA 23185
philvisser@yahoo.com
(757) 254-3017

LTC Margaret Nowicki
FA49; Mechanics & Materials Thread Leader
Formerly Strategic Adviser to the Dep. Asst. Sec.
Army for Marketing at the Army Research Group
margaret.nowicki@westpoint.edu
(845) 938-0635

Lucy Hair
Chemical Engineer, WMD expert and Team
Leader for Trinidad EleCent
Lawrence Livermore National Lab
hair1@llnl.gov
(925) 423-8545

Mike Deforest
USMA Class of 2007
Plant Manager
SMK Packaging
mike@smkpackaging.com
(619) 735-5300

Kevin Shipe
USMA Class of 2008
Automation Innovation Engineer
NALCO Champion
mike@smkpackaging.com
(281) 263-7335

Donald C. Glaser
President, Simulation Solutions, Inc.
179 Avenue at the Common
Shrewsbury, NJ 07702
dglaser@simulation-solutions.com
732-389-5400

Matthew Garvey
Simulation Solutions, Inc.
179 Avenue at the Common
Shrewsbury, NJ 07702
mgarvey@simulation-solutions.com
732-630-0611

Kisondra Waters
Associate, Global Energy and Power
Bank of America, Merrill Lynch
kisondra@gmail.com
(646) 743-2509

Patrick Underhill
Associate Professor of Chemical Engineering
Rensselaer Polytechnic Institute
underhill@rpi.edu
(518) 276-3032

Lynn Walker
Professor of Chemical Engineering
Carnegie Mellon University
lwalker@andrew.cmu.edu
(412) 268-3020

Kelly Schultz
Assistant Professor of Chemical Engineering
Lehigh University
Kes513@lehigh.edu
(610) 758-2012

Patrick Nonhof
Managing Partner
Provenance Consulting
patrick.nonhof@provenanceconsulting.com
(806) 273-5100

Anthony Hatfield
Consultant Engineer
Eli Lilly and Company
hatfield@lilly.com
(317) 655-0429

Matthew Libertore
Professor of Chemical Engineering
University of Toledo
Matthew.libertore@utoledo.edu
(419) 530-8267

Meeting the Needs of the Constituencies

Review of Relevant Army Literature

The United States Army is a very large organization with many components, and many of those components have teaching and/or training missions. The needs of the Army are expressed in published literature that is produced by various Army organizations. The chemical engineering program reviews those documents to ensure that our PEOs are consistent with Army needs. Examples include documents produced by the U.S. Army Training and Doctrine Command (TRADOC) and the Human Resources Command (HRC). The program also periodically reviews employment statistics drawn from the Office of Personnel Management and the government chemical engineering job attributes in postings on the USAJobs website. Specific examples are discussed below.

The U.S. Army Training and Doctrine Command (TRADOC) oversees the training of U.S. Army forces. TRADOC literature is intended to shape Army doctrine and to influence the Army's organization, training, materiel, leadership, education, and Soldier concerns. Officially, TRADOC recruits and trains soldiers, supports unit training, develops adaptive leaders, both soldier and civilian, guides the Army through doctrine, and shapes the Army by building and integrating formations, capabilities, and materiel." We feel that it is important for our program to periodically review TRADOC literature to ensure consistency.

Army *Field Manual 3-0 (FM 3-0)* "Operations" is the Army's capstone operations manual and is produced and periodically updated by TRADOC. FM 3-0 augments the Army's capstone doctrine on land operations, described in detail in Army Doctrine Publication 3-0 and Army Doctrine Reference Publication 3-0 (ADP 3-0 and ADRP 3-0). Together, these manuals describe the foundation for how Army forces conduct prompt and sustained large-scale operations. The most recent edition of FM 3-0, dated October 2017, reflects Army thinking in a complex era of persistent conflict. It describes The Army's operational concept of Unified Land Operations, which are simultaneous offensive, defensive, and stability operations. Each of these facets is described in detail. Anticipated operational environments (OEs, addressed in our PEO 2) are the foundational concept of the document and are described in Chapter 1 (pp. 1-4 to 1-6). Specifically, "Commanders and staffs analyze an OE using the eight operational variables: political, military, economic, social, information, infrastructure, physical environment, and time." These so-called "PMESII-PT" variables align very closely to the USMA APGs.

Army doctrine recognizes that military means alone are not sufficient to resolve these conflicts and that land power, while critical, is only one element of a broader campaign that represents the application of all the elements of national power. Because of this, Army doctrine gives equal importance to tasks focused on the population—stability or civil support—as it does to offensive and defensive operations. This parity is critical; it recognizes that conflict involves more than combat between armed opponents. While defeating the enemy with offensive and defensive operations, Army forces simultaneously shape the broader situation through stability actions to restore security and normalcy to the local populace. The stabilization phase is typically characterized by a shift in focus from sustained combat operations to stability operations. The intent of this phase of an operation is to help restore local political, economic, and infrastructure stability, which might include emergency infrastructure reconstruction [FM3-0, page 1-14]. The stabilization phase is illustrated in Figure 2-1 (shaded yellow) and occurs during all phases of the operation.

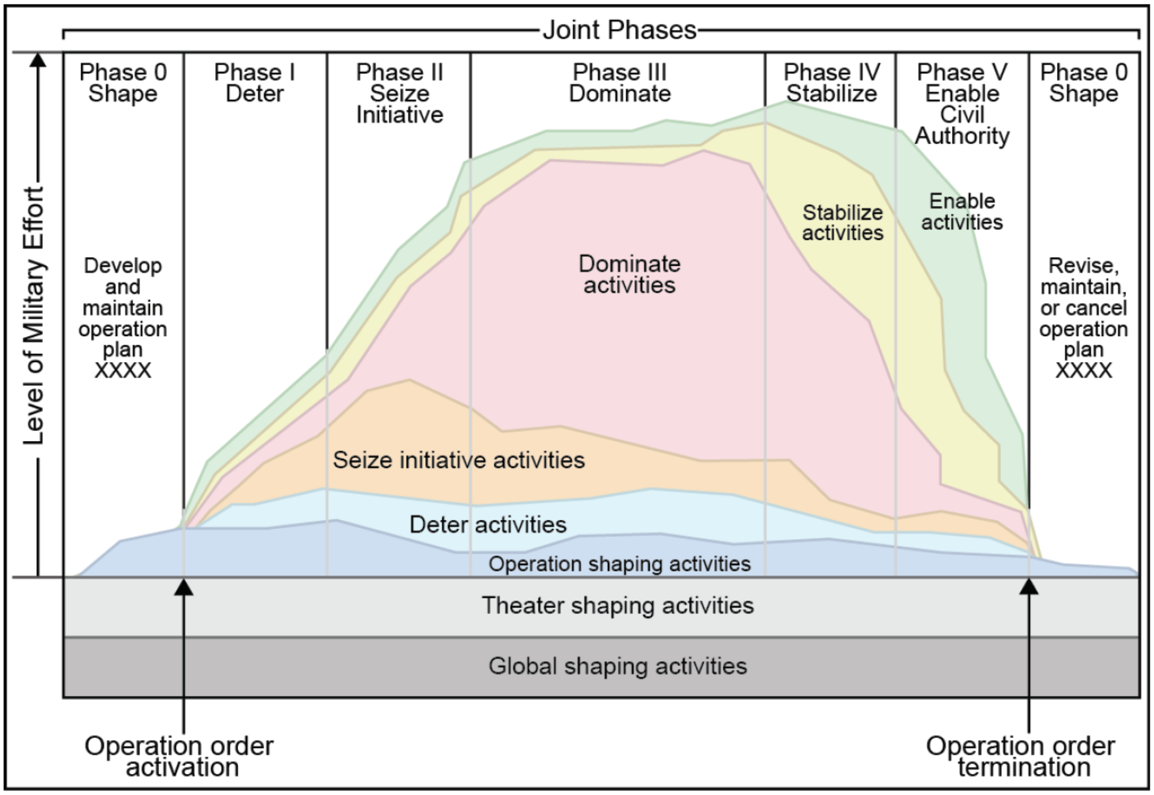


Figure 2-1. Large-scale combat joint phasing model from FM 3-0, Figure 1-3, page 1-12.

Two of the primary stability operations tasks – restoring essential services and support to economic and infrastructure development – have significant chemical engineering overlap. FM 3-0 states that "Stability operations are a core U.S. military mission that the Department of Defense shall be prepared to conduct and support. They shall be given priority comparable to combat operations and be explicitly addressed and integrated across all DoD activities including doctrine, organizations, training, education, exercises, materiel, leadership, personnel, facilities, and planning." Stability operations include activities that stabilize civilian populations, such as repair to water treatment, petroleum, natural gas, and electric production facilities. The Chemical Engineering PEOs overlap with this doctrine through PEO1, contributing to the solution of infrastructure or operational problems in a complex operational environment. PEO2, which states that our graduates succeed in graduate school or other advanced study programs, provides further and deeper subject matter expertise in advanced topical areas. Indirect support is also provided through PEO3, advancing their careers through clear and precise communication. The intent of this objective is to provide graduates with an ability to facilitate communication of important technical information between the Army's various decision-making authorities. Army officers must be able to communicate their technical expertise in a direct and understandable fashion to nontechnical professionals. PEO4, demonstrating effective leadership and chemical engineering expertise, is also related to stability operations through infrastructure tasks.

The specialized skills of a chemical engineer might also occur during the “seize initiative” phase of the operation, shaded orange in Figure 2-1. In combat, this involves conduction of reconnaissance, maintaining security, performing defensive and offensive tasks at the earliest possible time, forcing the enemy to culminate offensively, and setting the conditions for decisive operations. Operations to gain access to theatre infrastructure are an important aspect of this phase [FM 3-0, p. 1-13].

The program educational objectives also enable graduates to engage in direct support to other dimensions of full spectrum operations, including offensive and defensive operations, as defined by FM 3-0. Examples from such organizations as the Engineering, Logistics, and Chemical Branches are numerous, and include such activities as assessment and defense of chemical, petroleum, water, and power infrastructure for military operations, especially where such activities involve processing of biomass or fossil fuels, provision of petroleum and water to active duty combat troops, and assessment or remediation of chemical and biological threats on the battlefield. While our program is relatively new, we are actively engaged in outreach to these organizations to ensure that we are engaged with one of our principal constituencies.

An illustrative example of a complex operational environment in which Army personnel were engaged in combat in a refinery scenario occurred on February 7, 2018 at the Conoco refinery near Deir Al-Zour in Syria [“How a 4-Hour Battle Between Russian Mercenaries and U.S. Commandos Unfolded in Syria,” by Thomas Gibbons-Neff, New York Times, May 24, 2018]. The facility was captured from ISIS forces the previous year. Delta Force soldiers and Army Rangers from the Joint Special Operations Command were working alongside Kurdish and Arab forces at an outpost near the refinery, establishing secure conditions and maintaining the operation of the facility. Russian mercenaries, part of the Wagner Group, known by the nickname of the retired Russian officer who leads it, is in Syria to seize oil and gas fields and protect them on behalf of the Assad government. The mercenaries earn a share of the production proceeds from the oil fields they reclaim. In an effort to seize the facility, a column of Russian forces, including T-72 tanks, armored personnel carriers, and troop trucks, struck the outpost with a mixture of tank fire, large artillery and mortar rounds. The attack was suppressed by American warplanes striking in waves, including Reaper drones, F-22 and F-15 fighters, B-52 bombers, AC-130 gunships, and AH-64 Apache helicopters. Marine rocket artillery was also used. Ultimately, the attack was repulsed, with 200 to 300 of the attacking fighters killed and the others in retreat, while none of the Americans were harmed with the refinery suffering only minor damage.

Another Army organization that is very important for officer professional development is the U.S. Army Human Resources Command (HRC). HRC provides human resource services to soldiers, veterans, retirees and Army families. Within the HRC, the Officer Personnel Management Directorate provides active and reserve officers with career guidance and support. The Adjutant General Directorate manages soldiers' records, promotion boards, evaluation processing, personnel actions, entitlement programs, and veterans' support. The HRC is under the command of U.S. Army Deputy Chief of Staff (G-1), who reports to the Chief of Staff of the Army. The HRC produces and maintains

Department of the Army Pamphlet 600-3 (DA PAM 600-3), which contains relevant career counseling information for Army officers and enlisted personnel. DA PAM 600-3 is another document produced by "big Army" that provides insight into the thinking of the Army leadership about factors that influence career progression. The USMA chemical engineering program has reviewed this document to ensure that our PEOs are consistent with that thinking. DA PAM 600-3 is available online at the Army Publishing Directorate website at http://www.apd.army.mil/pdffiles/p600_3.pdf.

The purpose of DA PAM 600-3 is to assist Army officers with the development and management of their careers. This document describes the developmental opportunities an officer can expect for a successful career, as well as the attributes that the officer must achieve in order to access those opportunities. It provides very specific definitions and guidance for career development. For example, "leader development" is defined in the document as "the means for growing competent, confident, self-aware leaders who are prepared for the challenges of the future in combined arms joint, interagency, intergovernmental and multinational (JIIM) operations. Future Force leaders must be multifunctional, capable of supporting the range of military operations within the JIIM environment, comfortable with ambiguity, information systems literate, and capable of intuitive assessments of situations for rapid conceptualization of friendly courses of action." The characteristics and career milestones outlined in this document are consistent with the objectives of the Chemical Engineering Program at USMA.

To quantify the degree of alignment between our PEOs and the officer attributes described in DA PAM 600-3, we used our advisory board to review and compare the documents to our PEOs. The advisory board is very familiar with our PEOs and is also independent enough to provide an unbiased opinion. Since the entire document is 443 pages, it is too lengthy for one person to read and digest in a reasonable amount of time. We divided the document into portions and submitted them to each of our advisory board members. We then asked them to assess the degree of overlap between the various Army branch skill sets and the chemical engineering PEOs. A paper survey was used to capture the opinions of the advisory board members. The survey consisted of a grid containing the program objectives in the left column and the career field across the top row, arranged so that the reviewer could cross reference the PEOs with the career field. The board members were asked to use a 1-5 Likert scale to indicate the strength of the overlap between the two. The actual survey is shown in Table 2-2 below with sample career field identifying numbers entered as an example. The complete documentation is available to the visit team on request.

The results were averaged over all four objectives, and the results, as well as the Army branches that were included in the survey, are summarized in Figure 2-1. The career field (Army branch) is listed along the horizontal axis and the combined advisory board rating is plotted as vertical bars. A rating of 5 in the figure is the most favorable and 1 is least. The survey results show that in all cases, the board members ranked the degree of overlap greater than 4 out of five. The data was compiled and presented at the 2011 advisory board meeting. After discussions with the board members it is very clear that they feel that there is strong overlap between our program and the needs of those branches.

Table 2-2. Survey instrument used to collect data from the advisory board regarding the degree of overlap between PEOs and career field attributes.

For each PEO, rank from 1-5, where 5 indicates strong overlap with published officer characteristics and development milestones, and 1 indicates weak overlap.				
BLANK SAMPLE SURVEY	Functional Area (Army Branch)			
	47	12	91	89
During a career as commissioned officers in the United States Army and beyond, program graduates:				
1. Contribute to the solution of infrastructure or operational problems in a complex operational environment.				
2. Succeed in graduate school or other advanced study programs.				
3. Advance their careers through clear and precise technical communication.				
4. Demonstrate effective leadership and chemical engineering expertise.				

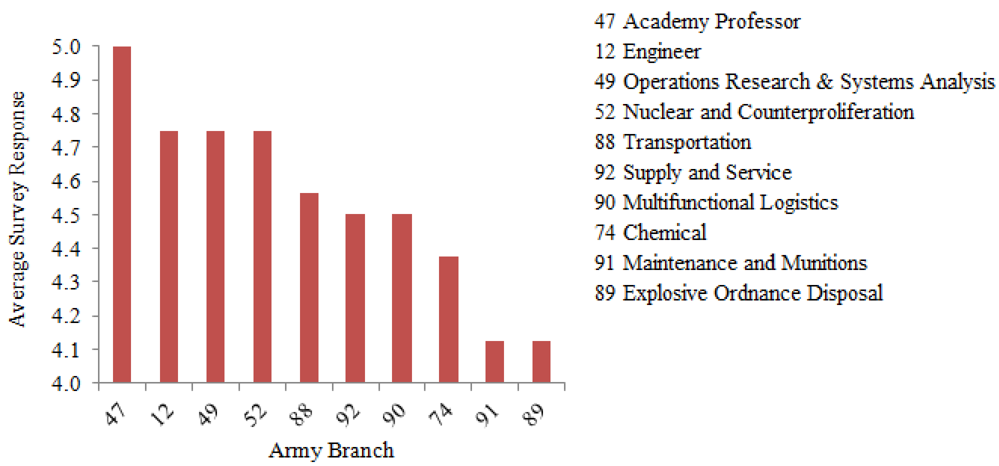


Figure 2-1. Degree of overlap between DA PAM 600-3 and PEOs.

Job Market Survey

We believe our graduates can function as chemical engineers within the military community. That is, we have identified a need within the Army and more generally within the Department of Defense, and our program is producing a product to help meet that need. Army requirements for chemical engineers are demonstrated by employment statistics that we collect and study. This information helps identify candidates for our advisory board and informs our thinking about the attributes and skills that are crafted into our objectives.

As in any process, a market survey is an important aspect of the design. These job market statistics are reported in this section.

At some point in their career, USMA chemical engineering graduates will leave the active duty Army and enter the civilian work force. Approximately half leave the Army after five years of service, so some of our graduates find themselves working as civilian engineers. It is important for us to keep our program relevant for all of our graduates, those who stay in the military and those who enter the civilian or government work force. The program provides a pool of prospective Army-engineers to potentially fill Army and government civilian chemical engineering jobs. Preparation for these jobs is an extension of the USMA mission. That is, being "prepared for a career of professional excellence and service to the nation" extends beyond the point at which our graduates leave the active duty Army.

The characteristics of government and Army chemical engineering job markets help to provide a picture of what the employment outlook is for our graduates when they are ready to transition into the civilian job market. The data is specific enough to identify the organizations where chemical engineers are employed. This, in turn, provides information about Army needs since these needs are reflected in the various missions and projects of these organizations. We can also access contact information to reach out on an individual basis. This type of data is very common and routinely published for civilian engineers. For an example, see the "2019 AIChE Salary Survey," *Chemical Engineering Progress*, June 2019, pp. 24-35. As far as we know, comparable data for government chemical engineers has never been published. So, while somewhat exhaustive, the data shown below is a presentation of comparable market survey data for chemical engineers working in the Army and in the government.

The U.S. Office of Personnel Management (OPM) has a data warehouse called Enterprise Human Resources Integration which takes in Human Resources and Transactional data on about 2 million federal employees. The data are processed to apply cancelled and corrected actions and then moved into the Enterprise Human Resources Statistical Data Mart (EHRI-SDM) which becomes the official reporting database. Coverage is fully explained at the OPM website (http://www.opm.gov/policy-data-oversight) under "Data, Analysis, and Documentation." The EHRI-SDM then provides the data for the online tool "FedScope" The data can be filtered using the Chemical Engineering occupation code (GS-0893) and then exported to spreadsheets for further analysis.

We were able to collect government employment data and identify specific Army agencies where chemical engineers are employed. The data are shown in Figure 2-2 through Figure 2-4. The data represents only GS Title 5 employees. The data does not include employment of Title 10 civilians, government contractors, government-owned-company-operated facilities, or civilian employees of the judicial branch.

Figure 2-2 shows the employment data for the U.S. Government, including all employees having a series GS-0893 (chemical engineer) designation, for the year 2018. It shows that there are currently 1,145 chemical engineers employed by the government. The Bureau of Labor Statistics reports that there are 32,700 chemical engineers employed in the United States as of 2016. This means that the government employs about 3.6% of all the chemical engineers in the country. The Department of Defense currently employs 800 chemical engineers, or about 70.1% of the government chemical engineering work force. Of these, 351 chemical engineers work for the Army, 384 for the Navy, 65 for the Air Force, and 15 for the Department of Defense. The 15 chemical engineers working for the Department of Defense work for the Office of the Secretary of Defense (1), the Defense Logistics Agency (12), and the Defense Advanced Research Projects Agency (2).

Figure 2-3 shows the current employment statistics for chemical engineers in U.S. Army agencies. There are 433 civilian chemical engineers currently employed by the Army, 334 of whom or 77% are employed by the Research, Development, and Engineering Command. This includes the Army Research Laboratory, Natick Soldier Research, Development and Engineering Center, Armament Research, Development and Engineering Center, Communication-Electronics Research, Development and Engineering Center, Aviation & Missile Development and Engineering Center, and the Edgewood Chemical Biological Center. Other employers include the Corps of Engineers (31), the Acquisition Support Center (12), Chemical Materials Agency (12), Test and Evaluation Command (10), Aviation and Missile Command (7), Joint Munitions Command (7), Materiel Acquisition Activities (5), Tank-Automotive and Armament Command (4), Field Operating Offices of the Secretary of the Army (3), Installation Management Command (2), Field Operating and Staff Support Agencies and (2), Communication Electronics Command (2), Intelligence and Security Command (1), and Materiel Readiness Activities (1). The Army Medical Command and the Office of the Secretary of the Army are currently at zero but have employed 1-2 chemical engineers each over the last five years.

The total employment data for the five years from 2008 to 2012 are shown in Figure 2-4 below. The figure compares the overall employment of chemical engineers in the government to the Departments of the Army, Navy, and Air Force. Army, Navy, and Air Force are shown in Figure 2-4, and can be seen to more or less follow the same trends seen government-wide. The data shows more or less constant employment, with some reduction seen during years 2010, 2011, and 2012. The individual Army sub-agencies are not shown in the figure but also more or less constant from year to year.

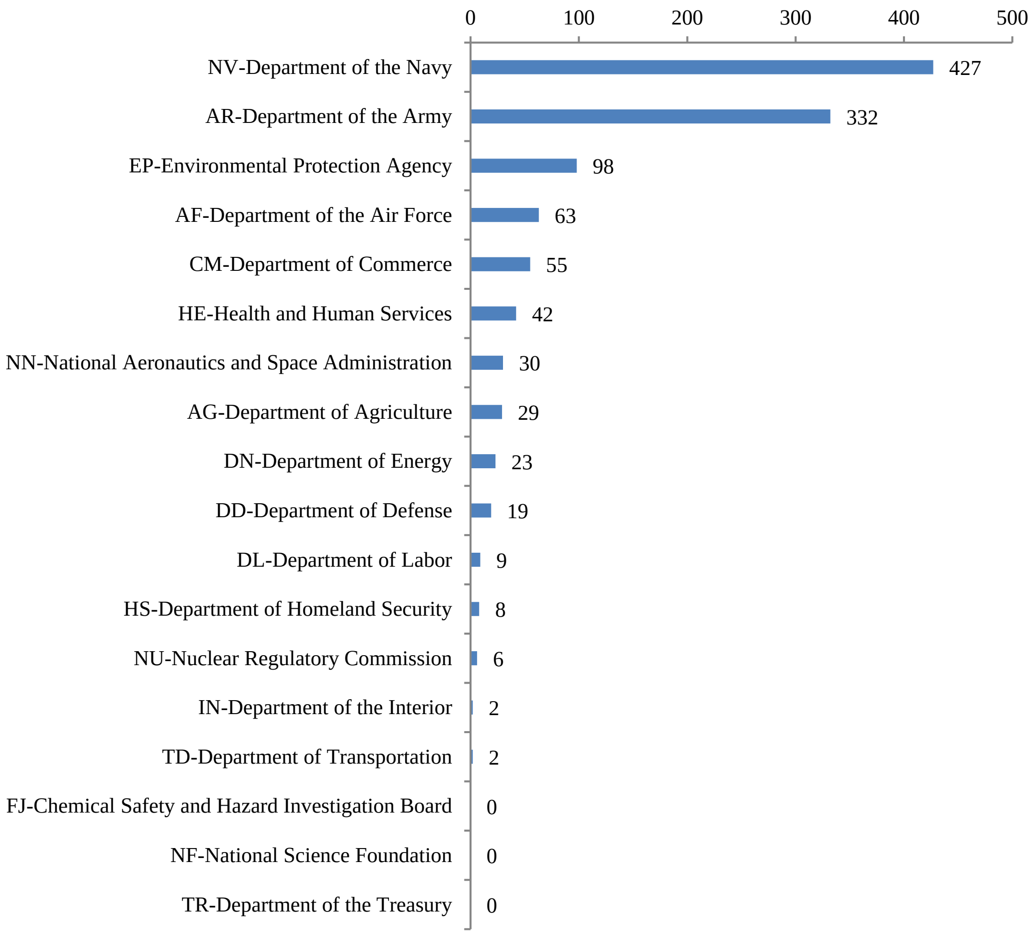


Figure 2-2. Number of chemical engineers employed by the U.S. Government in 2018. The Chemical Safety and Hazard Investigation Board, National Science Foundation, and Department of the Treasury are included because they employed at least one chemical engineer for two or more years over the past six years.

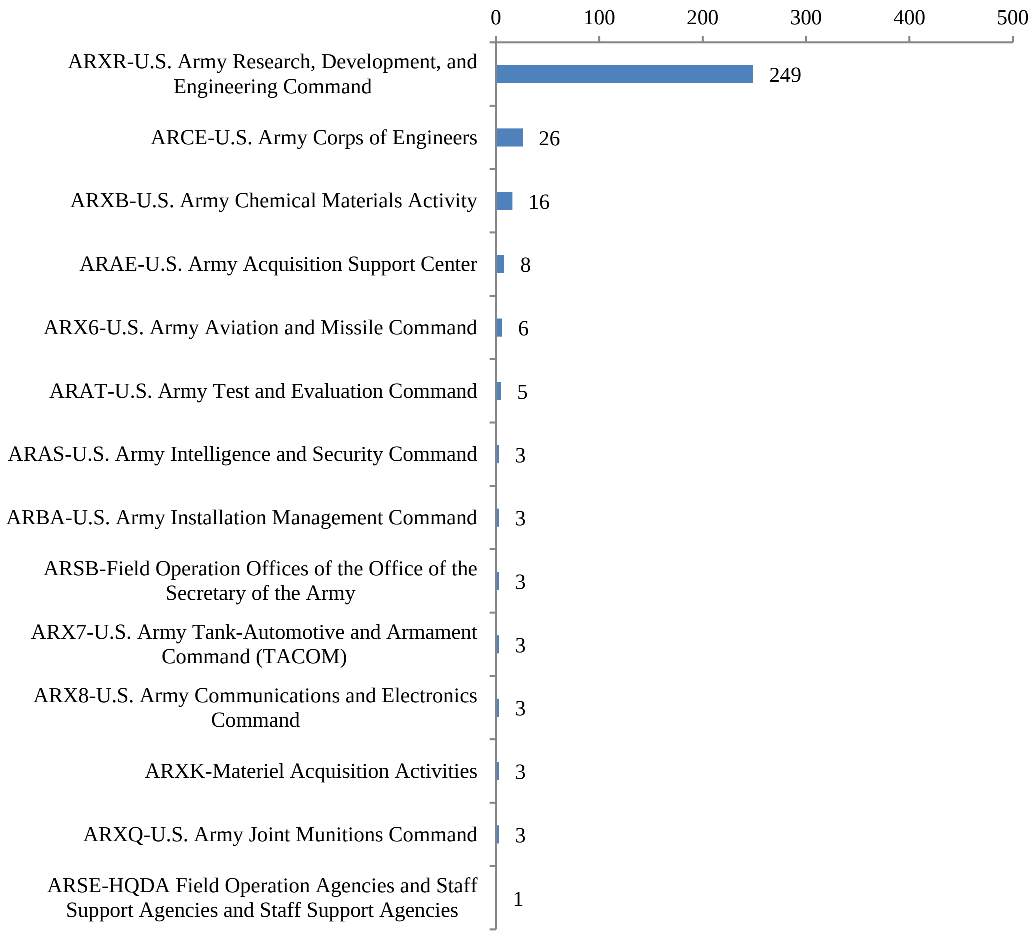


Figure 2-3. Location and number of chemical engineers employed by the U.S. Army in 2018.

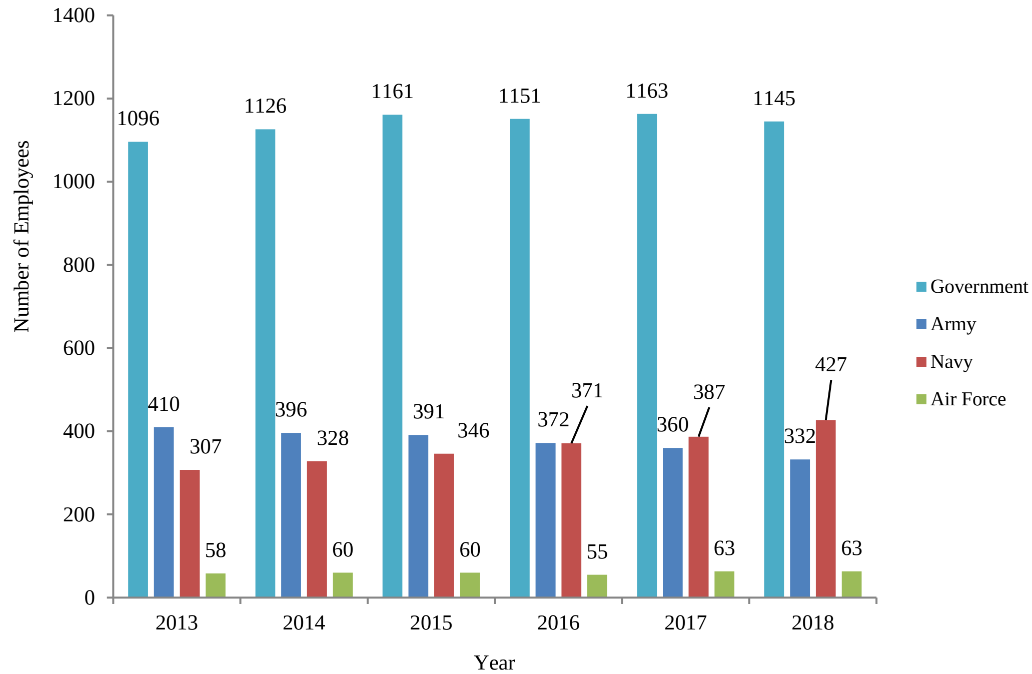


Figure 2-4. Total employment of chemical engineers by the U.S. Government, the U.S. Army, the U.S. Navy, and the U.S. Air Force from 2013 to 2018.

The data shown in Figure 2-2 to Figure 2-4 represent the total number of chemical engineers currently employed. The total employment numbers do not represent the dynamics of the sector; that is, hiring of new engineers or the separation of existing engineers through retirement or other attrition. To address this, we were able to track employment dynamics using FedScope to find out how many accessions and separations occurred each year from 2008 to 2012. These data are shown in Figure 2-5 below. The total number of new accessions in Figure 2-5 includes transfers in and new appointments. The total number of new separations in Figure 2-5 includes transfers out, reductions in force, removals, retirements, placements in non-pay status, and deaths. Overall, the data show that the number of new accessions is dropping over the last three years, both for the total government and the Army, while the number of separations is increasing. However, with relatively small numbers, year-to-year variations are to be expected. The five-year average is probably more informative. The Army is averaging about 25.2 new hires per year over the five-year period from 2008 to 2012, with 13.4 separations, while the total government figures are 65.2 and 45.5, respectively. In the Navy and Air Force, there has been an opposite trend over the last two years, with new hires slightly outpacing separations in both of those departments. The numbers can also be compared to the number of cadets we graduate each year, which has been averaging around 15-25 cadets per year. As many as half of these cadets, or around seven, will be looking for employment after their five-year service commitment is up. The job outlook in the government sector for chemical engineers is getting tougher, although local hiring is continuing in some departments and agencies.

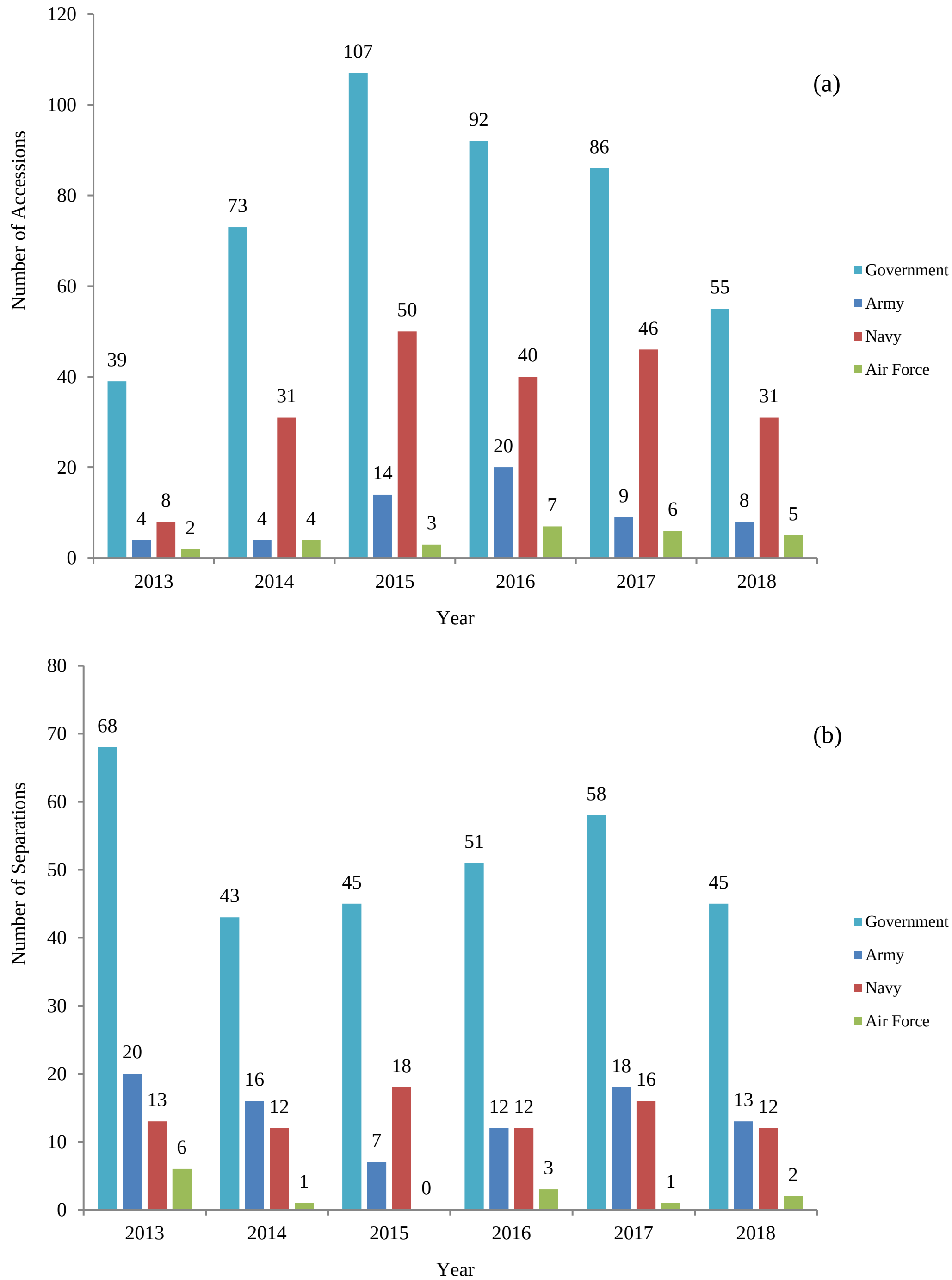


Figure 2-5. Army, Navy, Air Force and Government chemical engineering employment dynamics from 2013 to 2018, showing (a) Accessions, and (b) Separations.

Employment information can also be obtained by following job postings on the USAJobs website (https://www.usajobs.gov). The website can be easily configured to search for only chemical engineering positions, and then set to send out periodic email updates of new postings. The chemical engineering announcements for GS-0893 positions were followed for a six-month period. During that time, we counted 228 chemical engineering positions within the various Army agencies. Clearly some of these are redundant, but still contain useful information. Almost every job description is prefaced with a statement that civilian chemical engineers are sought because they have skills that are "not readily available in the military but serve a vital role in supporting the Army mission." Furthermore, all of the posting required a chemical engineering degree from an ABET-accredited program. Figure 2-6 summarizes the job data during this period. The specific Army organizations are listed along with the number of chemical engineering jobs in that organization. The data show a strong demand for chemical engineers in the Army, and this demand is one of the reasons for introducing chemical engineering as a program of study at the US Military Academy.

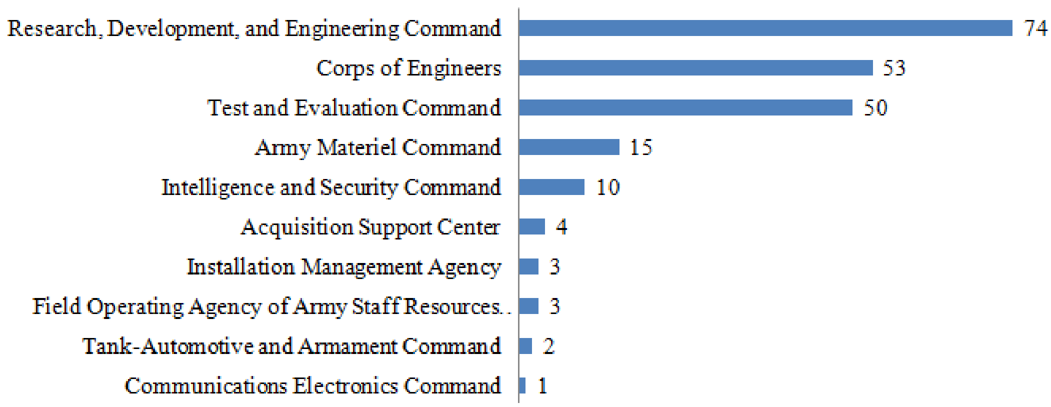


Figure 2-6. Number of job postings by organization for chemical engineers in Army organizations on USAJobs.

Statistics show that approximately 50% of our graduates will leave the active duty Army after their 5-year commitment. The jobs data are encouraging for our cadets and can be used by them for long-term career planning. Chemical engineering jobs in various Army agencies are ideally suited for them, and they are very competitive for these jobs. Many of the agency websites offer assistance in starting a career. For example, the Aviation & Missile Research, Development, and Engineering Center offers specific assistance for military personnel transitioning into civilian jobs. Furthermore, Veterans' Preference gives eligible veterans preference in appointment over many other applicants. Interestingly, all of the job announcements call for degrees from an accredited program, which underscores the importance of ABET to USMA chemical engineering. Also, all of the job postings emphasized the importance of the Fundamentals of Engineering Exam, which is closely aligned with our curriculum (see Criterion 5). The centralized clearing house for government-wide chemical engineering jobs (USAJobs) is definitely an important resource, and as our program matures, we expect significant numbers of our graduates to follow this career progression.

Early in their senior year, our students undergo branch selection. This is the process by which they select the branch of the Army in which they would like to serve. The process actually occurs over the course of the entire four years at the Academy, through a variety of data collection, self-assessment, and feedback activities, as discussed in Criterion 1. The process is outlined in Figure 1-1 and explained thoroughly in the "USMA Branching Program Mentor Guide" and other documents published by the Department of Military

Instruction (DMI), found on the USMA internal DMI SharePoint site at https://collab.westpoint.edu/dmi/Accessions/default.aspx. Note that internal network locations are not available from outside our network. The site is referenced here only to show how the information is made available for faculty to help them counsel cadets.

An Army officer's military branch has a significant influence on their career progression, and determines such things as career milestones, types of job assignments, and types of advanced schooling. During the branching process, students are encouraged to match their personal skill sets against the skills and talents identified by the branches. Desired kills, knowledge, behaviors, and talents are published by the branches and made available to the students. An example from the Engineer Branch is shown below in Figure 2-7.

Engineer — Year Group 2017

INTELLIGENCES: Interpersonal, Logical-Mathematical, Spatial

SKILLS: Engineer officers must possess an innate ability to evaluate and assess problems, the resident knowledge to brainstorm possibilities, and then quickly implement solutions to solve problems facing our maneuver commanders. This requires a design mindset – the ability to develop tasks and work processes for teams and motivate those teams to reach harmoniously, efficiently, and effectively desired outcomes. Officers must thrive in the world of abstract concepts and data-based reasoning, be able to discriminate and filter information of importance, and be capable of rapid visualization; all while skillfully possessing the ability to communicate concepts verbally or in writing. Collectively, these skills make Engineer officers superb problem solvers and invaluable to our Army and Nation.

KNOWLEDGE: The Engineer branch strongly desires officers with academic backgrounds in the domain-specific disciplines listed below, with particular emphasis on degrees that are accredited by the Accreditation Board for Engineering and Technology (ABET) and National Architectural Accrediting Board (NAAB). These disciplines provide a foundation in scientific and design methods that enable officers to become expert problem solvers.

- **RELEVANT EDUCATION PRIORITY 1:** ABET-EAC Engineering (Architectural, Civil, Mechanical, Electrical, Systems, Environmental, Chemical, Nuclear); NAAB Architecture; PAB Planning (Urban, City, Regional); ACCE Construction Management/Science; Engineering Management;GIS.
- **RELEVANT EDUCATION PRIORITY 2:** ABET-ETAC Engineering Technology; non-NAAB Architecture/Environmental Design; other Science, Technology, Engineering and Mathematics (STEM) disciplines.
- **RELEVANT EDUCATION PRIORITY 3:** All other disciplines.
- **RELEVANT TRAINING/EXPERIENCE:** Cadet Troop Leading Time / Leader Development Time (CTLT / CLDT) with Engineer Unit or Academic Enrichment Program in engineering or related activity (not all inclusive).

BEHAVIORS: (In addition to foundational)

ADAPTABLE	DEPENDABLE	INNOVATIVE	PROACTIVE
AMBITIOUS	DETAIL FOCUSED	INSPIRING	PROBLEM SOLVING
CHARISMATIC	DILIGENT	INTELLECTUALLY CURIOUS	TENACIOUS
COMMITTED	EXPERT	PERCEPTIVE	VISIONARY

TALENT PRIORITIES:

1. **DOMAIN-SPECIFIC EDUCATION:** Possessing a degree in engineering (ABET-preferred), architecture or environmental design (NAAB-preferred), construction management/science (ACCE-preferred), landscape architecture (LAAB preferred), planning (PAB-preferred), high performers in science, technology, engineering, and math (STEM) disciplines.
2. **PROJECT MANAGER:** Able to determine requirements, develop work processes, delegate responsibilities, and lead teams to desired outcomes.
3. **PROBLEM SOLVER:** Able to choose between best practices and unorthodox approaches to reach a solution. Accomplishes the task.
4. **INSPIRATIONAL LEADER:** Motivates teams to work harmoniously and productively towards a common goal.
5. **SPATIALLY INTELLIGENT:** Easily perceives, understands, and operates within the multi-dimensional world.

Approved by Branch Commandants, Certified by CAC Commander, Distributed by DCS-G1 DMPM, April 2016

Figure 2-7. Branching talents table for the Engineer Branch. This table and others like it for the other branches are provided to the cadets prior to choosing a major. References to ABET and Chemical Engineering are highlighted in yellow.

The Army maintains a database of personnel information on active duty officers, known as TOPMIS Database (Total Officer Personnel Management and Information System). CITRIX is the tool for connecting to TOPMIS to query for information and is available internally at https://mobile.hrc.army.mil/Citrix/XenApp/site/default.aspx. This site is not available to the general public. We can search the database and use undergraduate and graduate degree information to filter the data. For our graduates who are still in the Army, we are able to see their rank, what branch of the Army they are currently serving in, as well as their undergraduate degree, graduation year, year group, and contact information. The data are shown below in Figure 2-8 for all officers with a degree in chemical engineering.

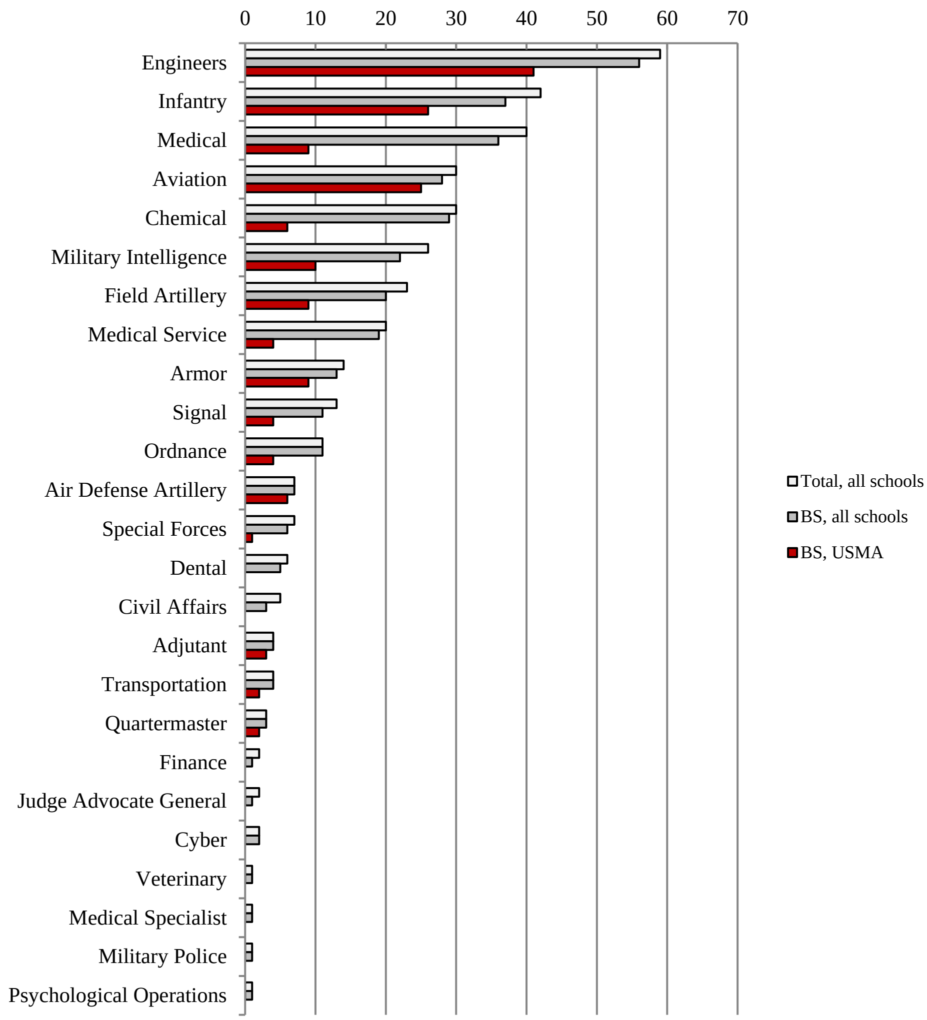


Figure 2-8. Current U.S. Army branch assignments for chemical engineering graduates.

The data show the branches where officers with chemical engineering degrees are currently serving in the Army, as well as the number of these officers serving in each branch. The Engineering Branch has the largest number of chemical engineers, with 59 chemical engineers, 56 of whom have a bachelors' degree, and 41 of those coming from our program. Many chemical engineers also serve in the infantry branch with 42 total and 37 bachelor's degree holders, 26 of whom graduated from USMA. The medical branch is third, with 40 total, 36 bachelors', 9 of whom are USMA grads. The highest percentage of bachelor's degrees from our program is in Aviation, where 25 of 28 or 89% of officers with degrees in chemical engineering graduated from our program.

This type of data is very useful to us. First, it tells us and our students where chemical engineers are currently serving in the Army. Secondly, as already discussed above, we align our PEOs with the career attributes in DA PAM 600-3. Third, an important piece of information also contained in the data is the "year group." The year group is a number assigned to the officer that depends on how rapidly they are promoted with respect to their peers. If they are selected for promotion ahead of or behind their peers for promotion, the year group can go up or down. So, by comparing the year group to the graduation year, we can determine if our graduates are ahead of, on par with, or behind their peers. This is most significant for graduates who have been promoted or are eligible to be promoted to the rank of Major or higher. As of 2019, the average difference between year group and graduation year is 0.00 for Army Majors who graduated from our program, meaning than all of them are on a satisfactory career trajectory, with no one "above the zone."

Direct Interactions with External Constituencies

There are several outreach activities in which students and faculty in the chemical engineering program interact directly with constituencies. These include field trips, student internships, faculty and student research, the student chapter of the AIChE, and enrollment of our instructors in civilian graduate school programs. We understand that PEOs are attained after graduation, and that the activities described in this section are either before graduation or are faculty activities. Also, there is no direct assessment of these activities. Nevertheless, they inform our students and faculty regarding the relevance of the program and the PEOs, by exposing them to practitioners in other Army agencies and in civilian academic and industrial settings.

Field trips serve to expose cadets and faculty to major plant operations and to the engineers and technical personnel working in them. Since USMA is a military base and many of our students are really still acclimating to the military lifestyle, they respond very positively to field trips because they provide some variety to their scheduled lifestyle as well as a small amount of time away from USMA. Field trips are usually organized by faculty and occur during the academic day. Extended overnight field trips are also possible on a more limited basis. Students attending field trips are not released from academic responsibilities in courses they miss as a result of attending the field trip. Administration of field trips is described in detail in DPOM 2-7. Examples of recent field trips include (in no particular order): The Hershey Company, Anheuser-Busch, Phillips Bayway refinery, Hess Port Reading Refinery, Indian Point nuclear power plant, Covant Energy waste to energy plant, Holston Army Ammunition Plant, Picatinny Arsenal, Hyde Park Brewery, Bristol Myers Squibb, Newburgh Brewery, and Krause's Chocolates. Many aspects of our curriculum are exhibited on the field trips, including plant design and layout, plant operations, control room operations, and many others.

Internships are known locally at USMA as Academic Individual Advanced Development (AIAD). The AIAD program allows students the opportunity to spend three to four weeks in the summer at one of a number of industrial, government, academic, and DoD facilities around the world. These internships are arranged by the faculty by direct interaction with the sponsors at the host organization. This usually involves direct coordination with the technical personnel that work with the cadets. In some cases, USMA faculty members work directly with human resources personnel at companies. Students participate as investigators in on-going technical projects, applying engineering science and design topics learned in the chemical engineering program. In some cases, students will continue the work during the academic year, either as an individual research or design project or as a capstone design project. Recent examples of AIADs where this has happened include Renewable Energy Group and Picatinny Arsenal.

Departmental research programs run by the faculty allow the students to work on contemporary problems for outside agencies. The faculty running these programs and projects may or may not be teaching chemical engineering courses, but the needs of the project allow them to work directly with chemical engineering students. There are many examples of ongoing chemical engineering or closely related projects in the department. Recent projects include: Production of syngas from biofuels for distributed energy production, in collaboration with the DoD's Strategic Environmental Research and Development Program (SERDP) and SUNY Cobbleskill; development of high-nitrogen energetic military pyrotechnics, in collaboration with the Pyrotechnics Technology and Prototyping Division at Picatinny Arsenal; and development and optimization of microbial fuel cells in collaboration with the Army Research Laboratory in Adelphi, MD. There are many other examples of ongoing research projects involving our students, and many of them will be on display as posters during the accreditation visit.

The student chapter of the American Institute of Chemical Engineers (AIChE) is an important activity that promotes interactions between our students and the civilian chemical engineering profession. The AIChE Club at USMA is sponsored by the Directorate of Cadet Activities (DCA), which provides official Academy recognition of the club, a budget for cadet activities, and promotion of the club on the DCA's website at https://westpoint.edu/military/directorate-of-cadet-activities/clubs/academic-clubs/american-institute-of-chemical-engineers. Club activities are numerous, and include field trips, educational and outreach activities, participation in local, regional and national meetings. The educational and outreach activities include beer brewing and chocolate making. The beer brewing and chocolate making projects are associated with several of the field trips and AIADs mentioned earlier. The beer project has also advanced to the point where the students are essentially running a small business, with DCA selling their beer in the Firstie Club and returning the proceeds to the DCA. Internships at Yuengling and Hershey's have resulted directly from these club activities. Also, both of these activities have been useful for allowing the students to learn how to better explain chemical engineering principles to the West Point community, forcing them to reflect more deeply on curricular concepts.

The rotating faculty development model is discussed in Criterion 6. Rotating faculty make up a significant fraction of the faculty complement at USMA with two distinct subgroups. The majority are Army officers assigned to teach at USMA after completing a master's degree at a civilian institution. The other group of rotating faculty is more senior, has already completed a first teaching tour at USMA, and completed a PhD program at a civilian institution. After completing the PhD, they return to USMA for a second teaching tour. These officers are thoroughly exposed to contemporary research and bring their distinctive views and experience to our program.

The activities described here are not assessed in any way. However, they are important dimensions to our program in the context of Criterion 2. They help to enrich the curriculum and provide avenues of contact between our students and faculty and outside scientists and engineers (our constituencies). In some cases, these activities are direct applications of lesson topics that the students have already seen or will soon see in the classroom. In many cases, the students are placed in close proximity to professionals in the field, providing role models and contacts for future career moves. For those reasons and others, we consider these outreach activities to be an important dimension of our program, and another way by which we connect to and interact with the larger Army and society.

E. Process for Review of the Program Educational Objectives

The process by which PEOs are reviewed begins with a periodic survey in which we ask several questions regarding the relevance and consistency of the PEOs with the Army and USMA missions. We survey the cadets, faculty, and advisory board. The results of the surveys are analyzed and reported back to the constituencies at program and department meetings and are also discussed at the advisory board meetings. This process has led to some improvements and revisions of the outcomes. In this section, we discuss the process by which the PEOs are reviewed and amended.

The Cadets. Each year, the cadets in the chemical engineering program review the PEOs and provide input regarding the relevance and consistency of program objectives to the Academy mission, to Army needs, and alignment of curriculum with objectives. The results of the last survey are shown below in Table 2-3. In addition to the surveys, the cadets also engage in interviews with the advisory board during the advisory board meetings. During the academic year, we have a program meeting with the cadets to discuss PEOs and the student outcomes. These discussions also serve to uncover any other issues with the program that the cadets would like to share verbally. The results of these surveys and discussions are reviewed by the faculty and presented to the advisory board.

The Faculty. The primary means by which faculty have input into the program objectives is through the same survey that occurs once per year, in tandem with the cadet survey mentioned above. These surveys assess faculty opinions on relevance of the objectives, consistency with the USMA and Army missions, and consistency of the curriculum and PEOs. The results of the last faculty survey are also shown in Table 2-3. Results of the surveys are discussed in faculty meetings and with the advisory board.

The Chemical Engineering Advisory Board. The advisory board meets annually to assist the chemical engineering program with assessment of PEOs, student outcomes, curriculum, and performance. At the time of writing of this report, the advisory board has met annually fourteen times since program inception, from 2006 through 2019, with the next meeting anticipated in April of 2020. Program educational objectives were initially drafted at the 2006 advisory board meeting, with significant revisions after discussions in 2008, 2009 and 2010. Changes in 2008 were in response to concerns about the breadth and language of the objectives, based on a recommendation that we clarify that the objectives to refer specifically to career progression after graduation. The advisory board made further recommendations in 2009 and 2010, and their help with rewording and the addition of a leadership objective in 2012 resulted in the present PEOs. These have more or less been in the same form since 2012, with minor revisions occurring in 2016. As mentioned above, the advisory board also participates in the PEO surveys and the most current results are also shown in Table 2-3 alongside the results from the cadets and faculty.

Table 2-3 and Figure 2-9 show the results of the surveys that were administered between 2014 and 2019 to the various constituencies. Earlier data is available on request, but the survey evolved several times before 2014, and the data were somewhat different and not readily comparable. The data demonstrate that the program has a process in place to periodically review the PEOs and how the program's constituencies are involved in the process.

Table 2-3. Summary of faculty, cadet, and advisory board surveys from the last review of the PEOs during AY19.

	AY2019 Results		
Survey Question ↓	**Faculty** (n=8)	**Advisory Board** (n=9)	**Cadets** (n=24)
1. The chemical engineering program objectives are consistent with the USMA mission.	5.00±0.00	5.00±0.00	4.88±0.34
2. The chemical engineering program objectives are consistent with Army needs.	4.88±0.35	4.89±0.33	4.46±0.59
3. The chemical engineering curriculum supports the program objectives.	5.00±0.00	4.78±0.44	4.75±0.44
4. The student outcomes are consistent with the program mission and objectives.	5.00±0.00	4.78±0.44	4.79±0.41
7. The survey methods used by the program are effective.	4.88±0.35	4.56±0.73	4.38±0.65
8. The cadets in the program are aware of the program educational objectives.	4.63±0.52	4.33±0.50	4.42±0.58
9. The cadets in the program have input into the development of the program educational objectives.	4.50±0.76	4.44±0.73	4.21±0.78
11. The faculty in the department are aware of the program educational objectives	4.88±0.35	5.00±0.00	4.88±0.34
12. The faculty in the department contribute to the development of the program outcomes and objectives.	4.88±0.35	4.89±0.33	4.83±0.38

Survey responses are on a 1-5 Likert scale, with a score of 1 being considered to be the lowest or most negative reply, and a 5 being the highest or most positive reply. The average responses are shown in the table and figure. The responses were generally very positive and were above 4 in almost all cases. The high scores by all constituencies under "consistency" questions (1-4) indicate that there is strong agreement that the objects are consistent with the Academy educational mission. Responses are somewhat lower in the "student awareness" questions (8 and 9).

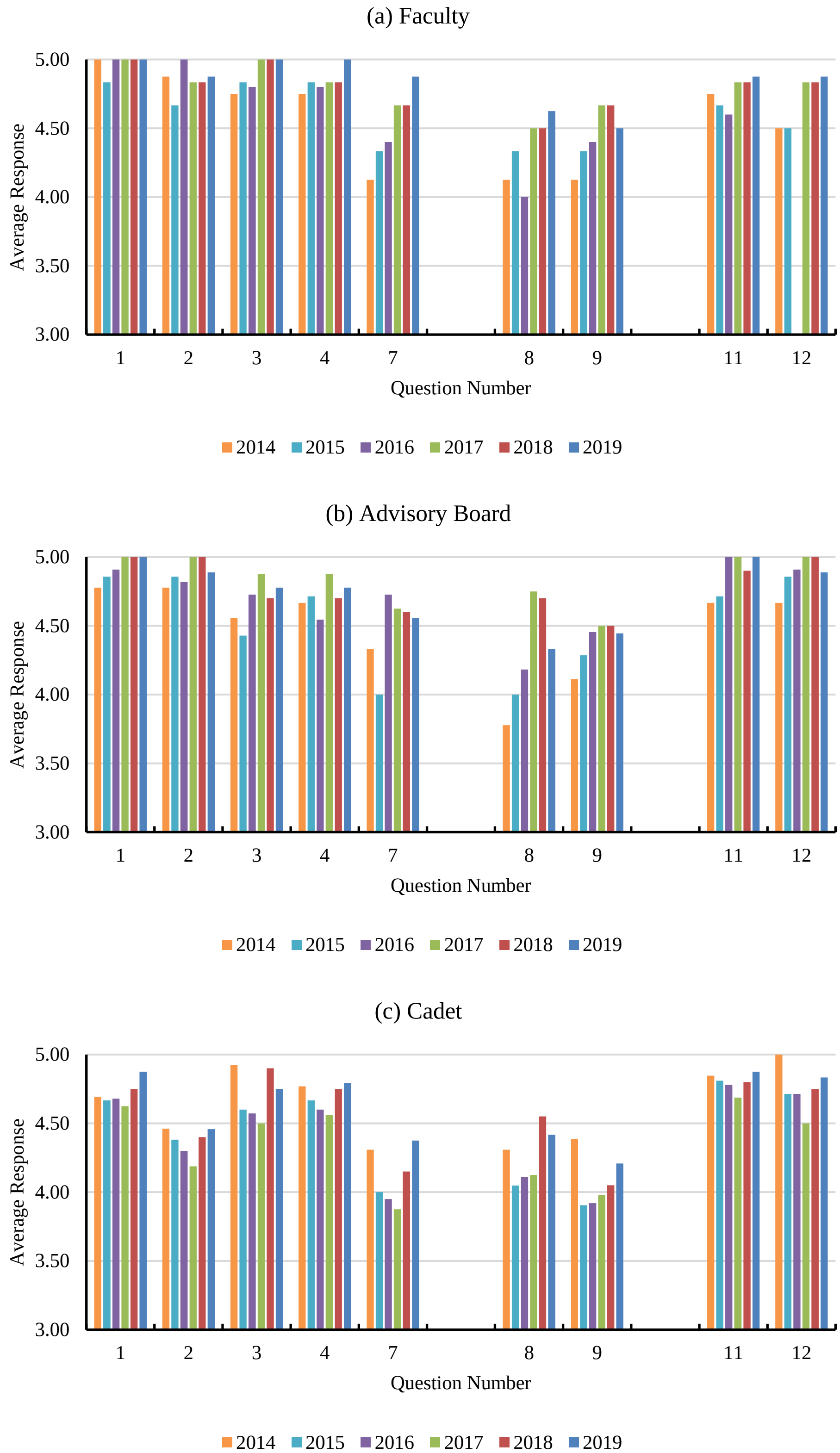


Figure 2-9. Year-to-year results of the PEO surveys from 2014 to 2019 for (a) faculty, (b) advisory board, and (c) cadets.

Frequent surveying of the students, at least once per year, is necessary to ensure that this constituency maintains an awareness of the PEOs and their role in the review process. While the students at West Point are generally mature as people and intellectually capable, they lack the career perspective and understanding of career attributes required to craft PEOs. Nevertheless, since they are a constituency, they are given a role in reviewing and commenting on them. Student responses to questions 1 to 4 and 11 and 12 are consistently very high and are comparable to the other two groups. They are relatively low in questions 7 and 8, dealing with awareness of and contributions to PEOs. This is most likely due to the very short lifetime of the students in the program. We survey seniors since they are the most advanced of the four year-groups and are most familiar with the USMA program. So, when students the following year are surveyed, they have no knowledge of the previous year. We have taken various measures to address this issue, including introduction to student outcomes and PEOs in lesson 1 of each class, and postings on course web pages, with limited improvement.

Summary

To summarize, in the preceding pages the program has shown how it has defined its PEOs and its constituencies, and how it interacts with those constituencies regarding the consistency and relevance of the PEOs. It has articulated the manner in which it reviews available literature and statistics from its primary constituency, the Army. The published literature includes documents such as FM 3-0 and PAM 600-3. The statistics include employment numbers and job postings for military and civilian chemical engineers in the Army as well as in the government at large. The program has also periodically and thoroughly surveyed its constituencies to ensure that the PEOs are meaningful to the Army. Using this information, the program has demonstrated that its PEOs are consistent with those needs and the mission of USMA. The results show clearly that there is a high degree of alignment between the program constituencies and the PEOs. Finally, the program has gathered feedback from its constituencies and used that feedback to periodically review and adjust the PEOs.

CRITERION 3. STUDENT OUTCOMES

A. Student Outcomes

[Page 3-1 to 3-3] List the student outcomes and state where they may be found by the general public as required by APPM Section I.A.6.a.   If the student outcomes used by the program are stated differently than those listed in Criterion 3, provide a mapping of the program's student outcomes to the student outcomes (1) through (7) listed in Criterion 3.   In the event that a program has not stated any student outcome verbatim as cited in the Engineering Accreditation Criteria, all elements required by that outcome must be retained. Further, the program must not alter the intent or otherwise diminish the meaning of that outcome.

B. Relationship of Student Outcomes to Program Educational Objectives

[Page 3-4 to page 3-6] Describe how the student outcomes prepare graduates to attain the program educational objectives.

[Red font page numbers added by USMA Chemical Engineering]

A. Student Outcomes.

The chemical engineering program has 8 student outcomes (SOs). Student outcomes 1-7 are identical to the general Criterion 3 student outcomes published by ABET under General Criteria in the EAC Criteria for Accrediting Engineering Programs (version 11-24-18). The program also has an addition student outcome (SO8). Student outcome 8 was developed by us to define the structure of the curriculum and reflect our interpretation of the program criteria for chemical engineering. The outcomes are listed below.

On completion of the chemical engineering program, our graduates demonstrate an ability to:

1. [ABET 1] Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. [ABET 2] Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. [ABET 3] Communicate effectively with a range of audiences.
4. [ABET 4] Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. [ABET 5] Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. [ABET 6] Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. [ABET 7] Acquire and apply new knowledge as needed, using appropriate learning strategies.
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances on chemical processes, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and stages separation processes, process dynamics and control, modern experimental and computing techniques, process design.

The student outcomes (SOs) can be found by the general public in the Academy's Redbook at https://courses.westpoint.edu/static/index.htm in Part 2: Disciplinary Offerings. The SOs are also available at https://www.westpoint.edu/ by clicking "Explore Academic Program," then "Majors and Minors on the left side of the web page, and then clicking "Chemical Engineering."

ABET student outcomes a-k were published in the EAC Criteria for Accrediting Engineering Programs in 2018-2019, and the new 1-7 in 2019-2020. The use of ABET 1-7 by our program began in AY2018, both sets of outcomes were used that year, and a full transition was implemented in AY2019. To facilitate the transition, we constructed a map of the old outcomes to the new. This mapping is shown in Table 3-1. This map demonstrates a continuous assessment process that bridges the transition and allowed us to transform assessment data for the old outcomes to the new.

Table 3-1. Mapping of ABET student outcomes a-k to ABET student outcomes 1-7.

ABET 1-7→ / ↓ ABET a-k	1. This course has improved my ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	2. This course has improved my ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	3. This course has improved my ability to communicate effectively with a range of audiences	4. This course has improved my ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	5. This course has improved my ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	6. This course has improved my ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	7. This course has improved my ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
a. This course has improved my ability to apply knowledge of mathematics, science, and engineering.	X						
b. This course has improved my ability to design and conduct experiments, as well as analyze and interpret data.						X	
c. This course has improved my understanding of how to design a system, a component of a system, or a process to meet desired needs		X					
d. This course has improved my ability to function on multidisciplinary teams.					X		
e. This course has improved my ability to identify, formulate, and solve engineering problems.	X						
f. As a result of this course, my understanding of professional and ethical responsibilities has improved.				X			
g. This course has helped me to communicate more effectively.			X				
h. This course has improved my understanding of the impact of engineering solutions in a global economic, environmental, and societal context				X			
i. This course has helped me recognize the need and develop the skills required for life-long learning.							X
j. This course has increased my knowledge of contemporary chemical engineering issues.							X
k. This course has improved my ability to use techniques, skills, and modern engineering tools necessary for engineering practice.							

B. Relationship of Student Outcomes to Program Educational Objectives

The PEOs are discussed in Criterion 2 and are listed again here for convenience. They state that during a career as commissioned officers in the United States Army and beyond, program graduates:

- Demonstrate effective leadership and chemical engineering expertise.
- Contribute to the solution of infrastructure or operational problems in a complex operational environment.
- Succeed in graduate school or other advanced study programs.
- Advance their careers through clear and precise technical communication.

The skills and knowledge obtained by the students in the program are learned in our courses prior to graduation. As the students progress through the program, course activities enable and strengthen their achievement of the SOs. The courses and curriculum are aligned with the SOs, and SOs are aligned with our PEOs. So, successful completion of the courses and associated activities in the curriculum imparts skills and attributes on the students that enable them to achieve the PEOs a few years after graduation. Criterion 5 of this self-study has a section that describes how the curriculum supports the attainment of the SOs. Alignment of the courses in the curriculum and the SOs is also discussed in Criterion 5. Assessment of the SOs is discussed in detail in Criterion 4.

The student outcomes provide our students a firm foundation from which they can develop further as graduates to achieve the Program Educational Objectives. The relationship between the SOs and the PEOs is illustrated in Table 3-2. (Table 3-2 is identical to Table 5-3 in Criterion 5.) Table 3-1 is a type of scope and sequence chart that shows the relationship between each SO and the corresponding PEO. The bullets (•) indicate the strongest relationship between a student outcome and a PEO. The table shows that each PEO is supported by multiple SOs.

Table 3-2 also shows that each SO can also support multiple PEOs. For example, the ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (SO1) enables effective leadership and chemical engineering expertise (PEO1). The ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (SO1) also enables contributions to the solution of infrastructure or operational problems in a complex operational environment (PEO2) and success in graduate school or other advanced study programs (PEO3). While not specifically indicated, there is also a relationship between all of the student outcomes and PEO4 (advancing careers through clear and precise technical communication) because clear and precise technical communication is enabled by each of these outcomes. For example, skills associated with effective teamwork (SO5), such as planning tasks, establishing goals, and meeting objectives both enables and is enabled by clear and precise technical communication.

Table 3-2. Mapping of Student Outcomes to Program Objectives.

(● designates alignment)		Chemical Engineering Program Educational Objectives: … leadership & chem. engineering expertise	… infrastructure and operational problems	… graduate school & advanced study progs.	… clear and precise tech. communication
↓ Chemical Engineering Student Outcomes		1	2	3	4
1	Identify, formulate, and solve….	●	●	●	
2	Apply engineering design …	●	●		
3	Communicate effectively …				●
4	Recognize ethical responsibilities …	●			
5	Function on effectively on a team …	●			
6	Develop and conduct experiments ...	●	●	●	
7	Acquire and apply new knowledge ...	●	●	●	
8	Understand the curriculum ….	●	●	●	

Another way to interpret Table 3-2 is in terms of a task analysis. That is, if one wishes to contribute to the solution of infrastructure or operational problems in a complex operational environment, then the activities that one might engage in include tasks associated with the indicated SOs.

In other words, to contribute to the solution of infrastructure or operational problems in a complex operational environment [PEO2], one might need to

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- Apply engineering design.
- Communicate effectively.
- Make informed judgments.
- Function effectively on a team.
- Analyze and interpret data and use engineering judgment to draw conclusions.
- Acquire and apply new knowledge.
- Understand the chemical engineering curriculum.

As another example, to succeed in graduate school or other advanced study programs [PEO3], it is important to be able to

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- Communicate effectively.
- Develop and conduct experiments, analyze and interpret data, and use engineering judgment to draw conclusions.
- Acquire and apply new knowledge.
- Understand the chemical engineering curriculum.
- Understand engineering science (curricular skills, SOs 12-20).

There are certainly other tasks, attributes and skills that one might use to attain our PEOs. A SO not listed as associated with a PEO does not mean that one cannot use that skill or attribute to attain the PEO. We are merely saying that there appears to be a more direct connection with the SOs indicated. For example, we do not have “understanding professional and ethical responsibilities” listed under “succeeding in graduate school or other advanced study programs.” No one would argue that there are certainly times, especially in academic research, where understanding of ethics is very important.

CRITERION 4. CONTINUOUS IMPROVEMENT

This section of your self-study report should document your processes for regularly assessing and evaluating the extent to which the student outcomes are being attained. This section should also document the extent to which the student outcomes are being attained. It should also describe how the results of these processes are being utilized to effect continuous improvement of the program.

Assessment is defined as one or more processes that identify, collect, and prepare the data necessary for evaluation. Evaluation is defined as one or more processes for interpreting the data acquired through the assessment processes in order to determine how well the student outcomes are being attained.

Although the program can report its processes as it chooses, the following is presented as a guide to help you organize your self-study report.

A. Student Outcomes

It is recommended that this section include (a table may be used to present this information):

1. [Pages 4-2 to 4-13] A listing and description of the assessment processes used to gather the data upon which the evaluation of each student outcome is based. Examples of data collection processes may include, but are not limited to, specific exam questions, student portfolios, internally developed assessment exams, senior project presentations, nationally-normed exams, oral exams, focus groups, industrial advisory committee meetings, or other processes that are relevant and appropriate to the program.
2. [Pages 4-15 to 4-36] The frequency with which assessment processes are carried out.
3. [Pages 4-15 to 4-36] The expected level of attainment for each student outcome.
4. [Pages 4-37 to 4-39] Summaries of the results of the evaluation process and an analysis illustrating the extent to which each student outcome is being attained.
5. [Page 4-3, 9, 13] How the results are documented and maintained.

B. Continuous Improvement

[Pages 4-40 to 4-48] Describe how the results of evaluation processes for the student outcomes and any other available information have been systematically used as input in the continuous improvement of the program. Describe the results of any changes (whether or not effective) in those cases where re-assessment of the results has been completed. Indicate any significant future program improvement plans based upon recent evaluations. Provide a brief rationale for each of these planned changes.

C. Additional Information

[Page 4-49] Copies of any of the assessment instruments or materials referenced in 4.A and 4.B must be available for review at the time of the visit. Other information such as minutes from meetings where the assessment results were evaluated and where recommendations for action were made could also be included.

[Red font page numbers and notes added by USMA Chemical Engineering]

A. Student Outcomes

The chemical engineering program evaluates and assesses many types of data related to performance on student outcomes. In general terms, the process used annually since 2006 includes:

- A robust and systematic assessment process that includes:
    - Chemical engineering course assessment (SO 1-8)
    - Mechanical engineering embedded indicators (SO 1, 3, 5, 6, and 7)
    - End of Semester Student Surveys (SO 1-7)
    - Fundamentals of Engineering Exam (SO 1, 4, 7, and 8)
    - Chemical Engineering Program Exit Survey (SO 1-8)
    - Completion of Cadet Character Education Program
    - Teamwork skills rubric (SO 5)
    - Lifelong learning skills rubric (SO 7)
    - Contemporary issues rubric (SO 7)
    - Course grades (SO 8)
- Flow of information from the course assessment to the program.
- Program-level assessment that includes discussions with the constituencies.
- Feedback to the program in the form of written reports.
- Systematic use of program assessments to make changes in the program.
- Reassessment of the program to measure the effects of the changes.

Section A of this report contains a listing and description of the assessment processes and instruments used to gather the data upon which the evaluation of each student outcome is based. This is followed by an out-come-by-outcome presentation of sample data for Academic Year 2019, including the frequency of assessment and expected levels of attainment. Section A concludes with a description of the summary and analysis of the results.

Chemical Engineering Course Assessment

Before discussing the course assessment process, it is important to briefly consider aspects of the faculty model at USMA relevant to the program improvement processes. Our faculty structure is different from what is normally seen in colleges and universities, so it helps to define some terms. All courses in our institution are assigned a primary faculty member who acts as the "course director" or CD. Other faculty members who teach in the same course are designated as "instructors." At USMA, the title "instructor" is also an academic rank. So, a person designated as an instructor in a course might have an academic rank of instructor, assistant professor, associate professor, or full professor. The course director is responsible for the administration of the course. That is, the CD is also an instructor that carries additional administrative duties as well as some authority to issue directives. The course director and the instructors are responsible for delivering the course. In small-enrollment courses like the chemical engineering electives, it is common to find a sole faculty member who is both CD and instructor. In that case, the administrative structure of the course is more or less the same as that used in other colleges and universities – one faculty member teaching one course. The CD is responsible for course assessment. Additional discussion of the faculty and how they are employed at USMA can be found in Criterion 6.

Course assessment is the first step in the overall program improvement process. Our department has adopted a standard course assessment procedure that is used in each course whether or not the course is taken by chemical engineers. All department CDs are required to complete the course assessment report within approximately 30 days of the completion of the course. The assessment reports are then archived by the department in electronic form on a shared network directory. The course assessment serves two purposes. First, it allows us to determine the level of achievement of student outcomes and course objectives, facilitating efforts to improve the course and the program. Second, the course assessment facilitates transitioning of the course from one faculty member to another, which is important in our institution because of the high turnover of the rotating faculty. The process is described in our "Course Director's Handbook," which is available for the evaluation team on request and is also shown in outline form in Table 4-**1**. Each entry in the table is normally a section in the narrative report.

The differently shaded columns in Table 4-**1** show the three main sections of the course assessment report. Section I is a description of the course, Section II contains the assessment, and Section III contains recommendations for course improvement. The course description in Section I is a listing of all of the important facets of the course, including the USMA Redbook (course catalog) entry, administrative information, and pedagogical information such as the course syllabus, course objectives, and connections to student outcomes. The assessment section (Section II) mirrors the structure of Section I but contains performance and survey data gathered by the CD, as well as any anecdotal assessments by the CD. Section III mirrors the format of the first two sections but contains recommendations for improvement where the CD identifies areas of concern. The final portion of the report is a printout of the "outcomes assessment workbook (excel file)" used to assess the level of achievement of the student outcomes covered in the course. An example of this is shown in Figure 4-**1** and Figure 4-**2** for academic year 2019, and details of the analysis follow in the narrative after the figures. Please note that this is a high-resolution image and can be zoomed when reading in electronic media to see the fine print. For explanations, selected sections will be expanded in additional figures in the narrative after the figures.

Table 4-1. Outline of the chemical engineering course assessment process.

SECTION I. COURSE DESCRIPTION: *This section summarizes the course, exactly as it was taught in the most recently completed semester.*	**SECTION II. COURSE ASSESSMENT** - *This section provides data and analysis to answer the following questions:*	**SECTION III. RECOMMENDED CHANGES** – *All proposed changes to the course, in each of the specified areas. Recommendations should be based on assessments from Section II.*
1. Redbook Description - *List the current Redbook description.*	**1. Redbook Description** - *Does the Redbook description match what is taught in the course?*	**1. Redbook Description**- *For changes, include a cut and paste Redbook entry and use "track changes" when submitting recommendation.*
2. Enrollment - *This AY and next AY (projected)*	**2. Enrollment** - *How does the student population compare from one year to the other? Assess effect of population on course.*	**2. Enrollment** - *Recommended teaching style considerations associated with the student population.*
3. Course Content - Abbreviated list of subjects or lesson blocks covered in the course (not the syllabus).	**3. Course Content** - *Is the course content appropriate?*	**3. Course Content** - *Recommended changes to course content.*
4. Course Objectives - *List course objectives here.*	**4. Course Objectives** - *Were the course objectives achieved? Do the course objectives cover the body of knowledge appropriately? Do the course objectives lend themselves to assessment?*	**4. Course Objectives** - *Recommended changes to objectives.*
	4a. Coverage - *Indicate coverage of objectives by graded events.*	**4a. Coverage –** *Recommended changes to coverage of objectives by graded events.*
	4b. Performance - *Indicate performance on course objectives.*	**4b. Performance** - **R***ecommendations to address shortcomings in performance on course objectives.*
5. Survey Questions - *List web-based and any other survey questions administered to cadets (If used).*	**5. Survey Questions** - *Are the survey questions appropriate?*	**5. Survey Questions** - *Recommended changes to survey questions.*
Examples include course questions, program questions, and USMA web-based survey questions.	**5a. Survey Results** – *Include analysis of Course-End Feedback or other surveys to include significant trends, suggestions, or input that you believe should be incorporated into the course in the future.*	**5a. Survey Results –** *Recommendations to address any shortcomings identified by survey results (if necessary).*
	5b. Survey Freeform Comments - *(If used.) Results of any free-form comments from cadets about the course – summarize the most prevalent positive and negative comments.*	**5b. Survey Freeform Comments** - *Recommendations to address shortcomings identified from free-form comments, if necessary.*
6. Course GPA - *List course GPA here. Include numbers from the last six terms.*	**6. Course QPA** – *Discuss any discernible trends or abrupt changes in course GPA over past several terms.*	**6. Course QPA –** *Recommendations to address any perceived problems.*
7. TEE Grade - *List course TEE grade here from the last six terms.*	**7. TEE Grade –** *Discuss any discernible trends or abrupt changes in TEE grade over past several terms.*	**7. TEE Grade –** *Recommendations to address concerns with TEE grades.*
8. Course Processes	**8. Course Processes**	**8. Course Process**
8a. Textbook - *Title, author, and edition*	**8a. Textbook** - *Is the current textbook appropriate?*	**8a. Textbook** - *Recommended changes to textbook.*
8b. Lessons and Labs - *List of lessons and labs in the course (syllabus).*	**8b. Lessons and labs** - *Are the number of lessons and labs appropriate?*	**8b. List of lessons and labs** - *Recommended changes to the number of lessons and labs.*
8c. Summary of Graded Requirements - *Number, type, and weight of drill problems, Problem Sets, Special Problems, EDP's, Lab Reports, Writs, WPR's, TEE, and Instructor Grade (as applicable).*	**8c. Summary of Graded Requirements** - *Are the graded requirements appropriate?*	**8c. Summary of Graded Requirements** - *Recommended changes to the graded requirements.*
8d. Areas of Special Emphasis - *Any special topics not included in the Redbook description or program embedded indicators go here.*	**8d. Areas of Special Emphasis** - *Are the areas of special emphasis appropriate?*	**8d. Areas of Special Emphasis** - *Recommended changes to the areas of special emphasis.*
9. Contribution to Student Outcomes - *List student outcomes here.*	**9. Contribution to the Student Outcomes** - *Does the course contribute to the student outcomes? How?*	**9. Contribution to Student Outcomes**
	9a. Coverage - *Indicate coverage of objectives by graded events.*	**9a. Coverage** - *Recommendations to address shortcomings in coverage of outcomes.*
	9b. Performance - *Indicate performance on course objectives.*	**9b. Performance** - *Recommendations to address problems in performance on student outcomes.*
10. Resources and Laboratories	**10. Resources and Laboratories**	**10. Resources and Laboratories**
10a. Laboratories - *List laboratories lab projects used in the course.*	**10a. Laboratories** - *Was equipment available for desired experiments? Was equipment working?*	**10a. Laboratories** - Recommendations to address any shortcomings in equipment.
10b. Computer Labs - *List computer labs used in the course.*	**10b. Computer Labs** - *Were adequate computing facilities available for the course?*	**10b. Computer Labs** - *Recommendations to improve computing facilities.*
10c. Physical Models & Demos - *List physical models and demos used in the course.*	**10c. Physical Models & Demos** - *Were physical models and demos adequate? In good working order?*	**10c. Physical Models & Demos** - *Recommendations for new demos or models, or to improve condition of existing models and demos.*
10d. Technician Support - *List technician support used in this course (wet lab or IT).*	**10d. Technician Support** - *Was technician support adequate?*	**10d. Technician Support** - *Recommendations to improve technician support.*
10e. Supplies - *List any wet lab or computer supplies used in this course.*	**10e. Supplies** - *Were supplies adequate?*	**10e. Supplies** - *Recommend additional supplies for this course.*
10f. Additional Facilities - *List any additional facilities used.*	**10f. Additional Facilities** - *Were the additional facilities adequate?*	**10f. Additional Facilities** - *Recommendations to address perceived shortcomings in additional facilities?*
10g. Unfunded Requests - *List any unfunded requests from last AY and whether or not they were funded.*	**10g. Unfunded Requests** - *If provided, were the items made available by the unfunded requirements adequate?*	**10g. Unfunded Requests** - *Recommendations for any additional unfunded requirements.*
11. Recommendations from last AY - *List recommendations from last year's course assessment and describe how they were implemented this AY.* *Go item by item from 1 through 10f.*		

Coverage
Student Outcomes
(Outcomes are abbreviated)

← Categories Input from Grades Spreadsheet →

Abbreviation Key: PS = Problem Set; DP = Design Problem; WPR = Written Partial Review; IPR = In-progress Review; PROJ = Capstone Design Project; TEE = Term-end Exam

	PS1 - PIPING	PS2 - PIPE SYS	PS3 - TANKS, C	PS4 - HT TX CC	PS5 - HT EXCH	PS6 - I/O ANAL	PS7 - COSTING	PS8 - COSTING	PS9 - DSPFWF	PS10 - ECON	PS TOT	DP1 - PIPING	DP2 - EXCH DE	DP3 - PROC DE	DP4 - BREAKE\	DP TOT
On completion of the program, our students have demonstrated that they can:																
id, form & solve by appl mse	1	1	1	1	1	1	1	1	1	1	1.0	1	0	0	1	0.5
design to meet needs	1	1	1	1	1	1	0	0	0	0	0.6	1	1	1	0	0.8
communicate	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0
professional ethical econ env context	0	0	0	0	1	1	1	1	1	1	0.6	0	1	1	0	0.5
function on a team	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0
experiments	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0
acquiring new knowledge	0	0	0	0	0	0	0	0	0	0	0.0	0	0	1	1	0.5
The program provides a thorough grounding and working knowledge of:																
chemistry	0	0	0	0	0	1	0	0	0	0	0.1	0	0	0	0	0.0
material & energy balances	1	0	0	1	0	1	0	0	0	0	0.3	0	0	0	0	0.0
safety & environmental	0	0	0	0	0	0	0	0	0	0	0.0	0	0	1	0	0.3
phys. & chem. thermo	1	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.0
heat, mass, & momentum transfer	0	0	0	1	0	0	0	0	0	0	0.1	0	0	0	0	0.0
chemical reaction engineering	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0
cont. & stage-wise separations	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0
process dynamics & control	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0
modern exp. & comp. tech.	0	1	0	1	1	1	1	1	0	0	0.6	1	1	1	1	1.0
process design	1	1	1	1	1	1	1	1	1	1	1.0	1	1	1	0	0.8
Course Objectives																
process development	0	0	0	0	1	1	1	0	0	0	0.3	1	1	1	1	1.0
assessing process economics	0	0	1	0	1	1	1	1	1	1	0.7	1	1	1	1	1.0
mechanical design	1	1	1	1	1	0	0	0	0	0	0.5	1	1	1	1	1.0
process simulators	0	0	0	0	1	0	0	0	0	0	0.1	1	1	1	1	1.0
writing design reports	0	0	0	0	1	0	0	0	0	0	0.1	0	0	0	0	0.0
safety and environmental	0	0	0	0	0	0	0	0	0	0	0.0	0	0	1	1	0.5
Raw Grade Data																
Average	99	92	90	94	73	85	97	90	86	96		92	96	96	97	

	A - HT TX & U	B - PIPE & COS	B - PUMP & CO	WPR1 TOT	ECON	DESIGN	SAFETY	WPR2 TOT	IFSAMSE	DESIGN	CONTEXT	SAFETY & ENV	TOOLS	IPR1 TOT
id, form & solve by appl mse	0	0	0	0.0	1	1	0	0.7	1	0	0	0	0	0.2
design to meet needs	1	1	1	1.0	0	0	0	0.0	0	1	0	0	1	0.4
communicate	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0.0
professional ethical econ env context	1	1	1	1.0	0	0	0	0.0	0	0	1	1	0	0.4
function on a team	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0.0
experiments	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0.0
acquiring new knowledge	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0.0
chemistry	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0.0
material & energy balances	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0.0
safety & environmental	0	0	0	0.0	0	0	1	0.3	0	0	0	1	0	0.2
phys. & chem. thermo	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0.0
heat, mass, & momentum transfer	1	0	1	0.7	0	0	0	0.0	0	0	0	0	0	0.0
chemical reaction engineering	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0.0
cont. & stage-wise separations	0	0	0	0.0	0	0	0	0.0	0	1	0	0	0	0.2
process dynamics & control	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0.0
modern exp. & comp. tech.	1	0	1	0.7	0	0	0	0.0	0	0	0	0	1	0.2
process design	1	0	1	0.7	0	1	0	0.3	0	1	0	0	1	0.4
process development	1	1	1	1.0	0	1	0	0.3	0	1	0	0	1	0.4
assessing process economics	1	1	1	1.0	1	0	0	0.3	0	0	0	0	0	0.0
mechanical design	1	1	1	1.0	0	0	0	0.0	0	1	0	0	0	0.2
process simulators	1	1	1	1.0	0	0	0	0.0	0	0	0	0	1	0.2
writing design reports	0	0	0	0.0	0	0	0	0.0	0	0	0	0	0	0.0
safety and environmental	0	0	0	0.0	0	0	0	0.0	0	0	0	1	0	0.2
Average	78	86	96		80	77	93		99	92	99	99	75	

	IFSAMSE	DESIGN	COMMUN	CONTEXT	KNOW	SAFETY & ENV	CONTROL	TOOLS	IPR2 TOT	IFSAMSE	DESIGN	COMMUN	CONTEXT	KNOW	SAFETY & ENV	CONTROL	TOOLS	PROJ TOT	DESIGN	ECON	TEE TOT
id, form & solve by appl mse	1	0	0	0	0	0	0	0	0.1	1	0	0	0	0	0	0	0	0.1	1	0	0.5
design to meet needs	0	1	0	0	0	0	0	0	0.1	0	1	0	0	0	0	0	0	0.1	1	1	1.0
communicate	0	0	1	0	0	0	0	0	0.1	0	0	1	0	0	0	0	0	0.1	0	0	0.0
professional ethical econ env context	0	0	0	1	0	0	0	0	0.1	0	0	0	1	0	0	0	0	0.1	0	1	0.5
function on a team	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
experiments	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
acquiring new knowledge	0	0	0	0	1	0	0	0	0.1	0	0	0	0	1	0	0	0	0.1	0	0	0.0
chemistry	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	1	0	0.5
material & energy balances	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
safety & environmental	0	0	0	0	0	1	0	0	0.1	0	0	0	0	0	1	0	0	0.1	0	0	0.0
phys. & chem. thermo	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
heat, mass, & momentum transfer	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
chemical reaction engineering	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
cont. & stage-wise separations	0	1	0	0	0	0	0	0	0.1	0	1	0	0	0	0	0	0	0.1	1	0	0.5
process dynamics & control	0	0	0	0	0	0	1	0	0.1	0	0	0	0	0	0	1	0	0.1	0	0	0.0
modern exp. & comp. tech.	0	0	0	0	0	0	0	1	0.1	0	0	0	0	0	0	0	1	0.1	1	1	1.0
process design	0	1	0	0	0	0	0	1	0.3	0	1	0	0	0	0	0	1	0.3	1	1	1.0
process development	0	1	0	0	0	0	1	1	0.4	0	1	0	0	0	0	1	1	0.4	1	1	1.0
assessing process economics	0	0	0	1	0	0	0	0	0.1	0	0	0	1	0	0	0	0	0.1	0	1	0.5
mechanical design	0	1	0	0	0	0	0	1	0.3	0	1	0	0	0	0	0	1	0.3	1	1	1.0
process simulators	0	1	0	0	0	0	0	1	0.3	0	1	0	0	0	0	0	1	0.3	1	1	1.0
writing design reports	0	0	1	0	0	0	0	0	0.1	0	0	1	0	0	0	0	0	0.1	0	0	0.0
safety and environmental	0	0	0	0	0	1	0	0	0.1	0	0	0	0	0	1	0	0	0.1	0	0	0.0
Average	67	69	37	60	68	63	62	70		83	79	79	85	71	79	83	79		91	95	

← Data Carried Forward from Grades Spreadsheet →

Figure 4-1. Part 1 of the student outcomes assessment workbook (excel file) showing the course director's assessment of coverage of course objectives and student outcomes. This is the "coverage" portion of the workbook.

Performance
Student Outcomes
(Outcomes are abbreviated)

Abbreviation Key: PS = Problem Set; DP = Design Problem; WPR = Written Partial Review; IPR = In-progress Review; PROJ = Capstone Design Project; TEE = Term-end Exam

	PS1 - PIPING	PS2 - PIPE SYS	PS3 - TANKS, C	PS4 - HT TX CC	PS5 - HT EXCH	PS6 - I/O ANAL	PS7 - COSTING	PS8 - COSTING	PS9 - DSPFWF	PS10 - ECON	PS TOT	DP1 - PIPING	DP2 - EXCH DE	DP3 - PROC DE	DP4 - BREAKE\	DP TOT
On completion of the program, our students have demonstrated that they can:																
id, form & solve by appl mse	99	92	90	94	73	85	97	90	86	96	90	92	0	0	97	95
design to meet needs	99	92	90	94	73	85	0	0	0	0	89	92	96	96	0	95
communicate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
professional ethical econ env context	0	0	0	0	73	85	97	90	86	96	88	0	96	96	0	96
function on a team	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
experiments	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
new knowledge	0	0	0	0	0	0	0	0	0	0	0	0	0	96	97	97
The program provides a thorough grounding and working knowledge of:																
chemistry	0	0	0	0	0	85	0	0	0	0	85	0	0	0	0	0
material & energy balances	99	0	0	94	0	85	0	0	0	0	93	0	0	0	0	0
safety & environmental	0	0	0	0	0	0	0	0	0	0	0	0	0	96	0	96
phys. & chem. thermo	99	0	0	0	0	0	0	0	0	0	99	0	0	0	0	0
heat, mass, & momentum transfer	0	0	0	94	0	0	0	0	0	0	94	0	0	0	0	0
chemical reaction engineering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cont. & stage-wise separations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
process dynamics & control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
modern exp. & comp. tech.	0	92	0	94	73	85	97	90	0	0	89	92	96	96	97	95
process design	99	92	90	94	73	85	97	90	86	96	90	92	96	96	0	95
Course Objectives																
process development	0	0	0	0	73	85	97	0	0	0	85	92	96	96	97	95
assessing process economics	0	0	90	0	73	85	97	90	86	96	88	92	96	96	97	95
mechanical design	99	92	90	94	73	0	0	0	0	0	90	92	96	96	97	95
process simulators	0	0	0	0	73	0	0	0	0	0	73	92	96	96	97	95
writing design reports	0	0	0	0	73	0	0	0	0	0	73	0	0	0	0	0
safety and environmental	0	0	0	0	0	0	0	0	0	0	0	0	0	96	97	97

	A - HT TX & U	B - PIPE & COS	B - PUMP & CO	WPR1 TOT	ECON	DESIGN	SAFETY	WPR2 TOT	IDFMSE	DESIGN	CONTEXT	SAFETY & ENV	TOOLS	IPR1 TOT
id, form & solve by appl mse	0	0	0	0	80	77	0	79	99	0	0	0	0	0
design to meet needs	78	86	96	86	0	0	0	0	0	92	0	0	75	75
communicate	0	0	0	0	0	0	0	0	0	0	0	0	0	0
professional ethical econ env context	78	86	96	86	0	0	0	0	0	0	99	99	0	99
function on a team	0	0	0	0	0	0	0	0	0	0	0	0	0	0
experiments	0	0	0	0	0	0	0	0	0	0	0	0	0	0
new knowledge	0	0	0	0	0	0	0	0	0	0	0	0	0	0
chemistry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
material & energy balances	0	0	0	0	0	0	0	0	0	0	0	0	0	0
safety & environmental	0	0	0	0	0	0	93	93	0	0	0	99	0	99
phys. & chem. thermo	0	0	0	0	0	0	0	0	0	0	0	0	0	0
heat, mass, & momentum transfer	78	0	96	87	0	0	0	0	0	0	0	0	0	0
chemical reaction engineering	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cont. & stage-wise separations	0	0	0	0	0	0	0	0	0	92	0	0	0	0
process dynamics & control	0	0	0	0	0	0	0	0	0	0	0	0	0	0
modern exp. & comp. tech.	78	0	96	87	0	0	0	0	0	0	0	0	75	75
process design	78	0	96	87	0	77	0	77	0	92	0	0	75	75
process development	78	86	96	86	0	77	0	77	0	92	0	0	75	75
assessing process economics	78	86	96	86	80	0	0	80	0	0	0	0	0	0
mechanical design	78	86	96	86	0	0	0	0	0	92	0	0	0	0
process simulators	78	86	96	86	0	0	0	0	0	0	0	0	75	75
writing design reports	0	0	0	0	0	0	0	0	0	0	0	0	0	0
safety and environmental	0	0	0	0	0	0	0	0	0	0	0	99	0	99

	IDFMSE	DESIGN	COMMUN	CONTEXT	KNOW	SAFETY & ENV	CONTROL	TOOLS	IPR2 TOT	IDFMSE	DESIGN	COMMUN	CONTEXT	KNOW	SAFETY & ENV	CONTROL	TOOLS	PROJ TOT	DESIGN	ECON	TEE TOT
id, form & solve by appl mse	67	0	0	0	0	0	0	0	67	83	0	0	0	0	0	0	0	83	91	0	91
design to meet needs	0	69	0	0	0	0	0	0	69	0	79	0	0	0	0	0	0	79	91	95	93
communicate	0	0	37	0	0	0	0	0	37	0	0	79	0	0	0	0	0	79	0	0	0
professional ethical econ env context	0	0	0	60	0	0	0	0	60	0	0	0	85	0	0	0	0	85	0	95	95
function on a team	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
experiments	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
new knowledge	0	0	0	0	68	0	0	0	68	0	0	0	0	71	0	0	0	71	0	0	0
chemistry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91	0	91
material & energy balances	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
safety & environmental	0	0	0	0	0	63	0	0	63	0	0	0	0	0	79	0	0	79	0	0	0
phys. & chem. thermo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
heat, mass, & momentum transfer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
chemical reaction engineering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cont. & stage-wise separations	0	69	0	0	0	0	0	0	69	0	79	0	0	0	0	0	0	79	91	0	91
process dynamics & control	0	0	0	0	0	0	62	0	62	0	0	0	0	0	0	83	0	83	0	0	0
modern exp. & comp. tech.	0	0	0	0	0	0	0	70	70	0	0	0	0	0	0	0	79	79	91	95	93
process design	0	69	0	0	0	0	0	70	70	0	79	0	0	0	0	0	79	79	91	95	93
process development	0	69	0	0	0	0	62	70	67	0	79	0	0	0	0	83	79	80	91	95	93
assessing process economics	0	0	0	60	0	0	0	0	60	0	0	0	85	0	0	0	0	85	0	95	95
mechanical design	0	69	0	0	0	0	0	70	70	0	79	0	0	0	0	0	79	79	91	95	93
process simulators	0	69	0	0	0	0	0	70	70	0	79	0	0	0	0	0	79	79	91	95	93
writing design reports	0	0	37	0	0	0	0	0	37	0	0	79	0	0	0	0	0	79	0	0	0
safety and environmental	0	0	0	0	0	63	0	0	63	0	0	0	0	0	79	0	0	79	0	0	0

Figure 4-2. Part 2 of the student outcomes assessment workbook (excel file) showing performance on those graded events where there is corresponding coverage of course objectives and student outcomes. This is the "performance" portion of the process.

Identification, Collection, and Preparation. Course directors are first asked to identify projects, homework problems, exam questions, reports, presentations, and other activities that can be used to assess the level of achievement of student outcomes (embedded indicators). They do this by determining whether or not the graded event is related to the student outcomes. They are also asked to justify the relationship to the outcome, and these justifications are developed with the program assessment coordinator. During the semester, the course directors keep records of specific grades for each graded event (or portions of graded events). At the end of the semester, as part of the course assessment process, course directors complete the outcomes assessment workbook (excel file) that relates the graded events to the student outcomes, Figure 4-**1** and Figure 4-**2**. The workbook then calculates the average level of achievement for each student outcome covered by the course.

Course Director's Evaluations. The student outcomes and course objectives are listed in the first column of the worksheet. The graded events, or components of each graded event, are listed in the top row. Each graded event then represents a column in the worksheet. For each graded event, the course director assigns either a 1 or a 0 in the row for each corresponding outcome. A mark of "1" indicates coverage of the outcome, and lack of coverage is indicated with a "0." For example, if a specific homework problem requires the students to identify, formulate, and solve a complex problem by applying principles of math, science, and engineering, the course director would enter a "1" in the row for that problem set, in the cell at the intersection of the appropriate row and column. A small portion of the assessment worksheet is magnified and shown in Figure 4- **3** to illustrate this step. Referring to the figure, the outcome is shown in cell A7. The "1" in cell C7 indicates that in the opinion of this course director, there is a significant element of that outcome in that graded event.

	A	B	C	D	E	F	G	H	I	J	K	L	M
			PS = Problem Set (Homework)										
1	**Coverage**		PS1	PS2	PS3	PS4	PS5	PS6	PS7	PS8	PS9	PS10	PS TOT
2	**Student Outcomes**												
3	(Outcomes are abbreviated)												
4													
5	On completion of the program, our students have demonstrated that they can:												
6													
7	id, form & solve by appl mse		1	1	1	1	1	1	1	1	1	1	1.0

Figure 4- 3. Expanded view of the upper left portion of Figure 4-1 showing assignment of outcome coverage.

After all of the graded events are analyzed in this manner, the result is a matrix that allows us to quantify the degree of coverage. The average of the 1 or 0 ratings over all graded events gives us a measure of the frequency of coverage for each specific outcome. This then would complete the first part of the CD's input to the program assessment.

A graphical roll-up of the coverage worksheet is shown in Figure 4-**4**. This is an example from one course. The details in the figure are slightly different for each course since each CD customizes his or her analysis in the manner described above. The plot shows which graded events have coverage of which student outcome. For example, the design outcome has coverage in seven of the eight types of graded events in the course, which makes sense since this is a design course. The specific type and location of coverage is designated in the "coverage" worksheet, Figure 4-**1**. The red circles are an important feature of the plot. They designate program-level student outcomes that the CD must cover in this course in order to ensure overall coverage of the student outcomes in the program. This is determined by the program assessment coordinator after examination of all the course assessment files and is discussed with the CD during the planning of the course.

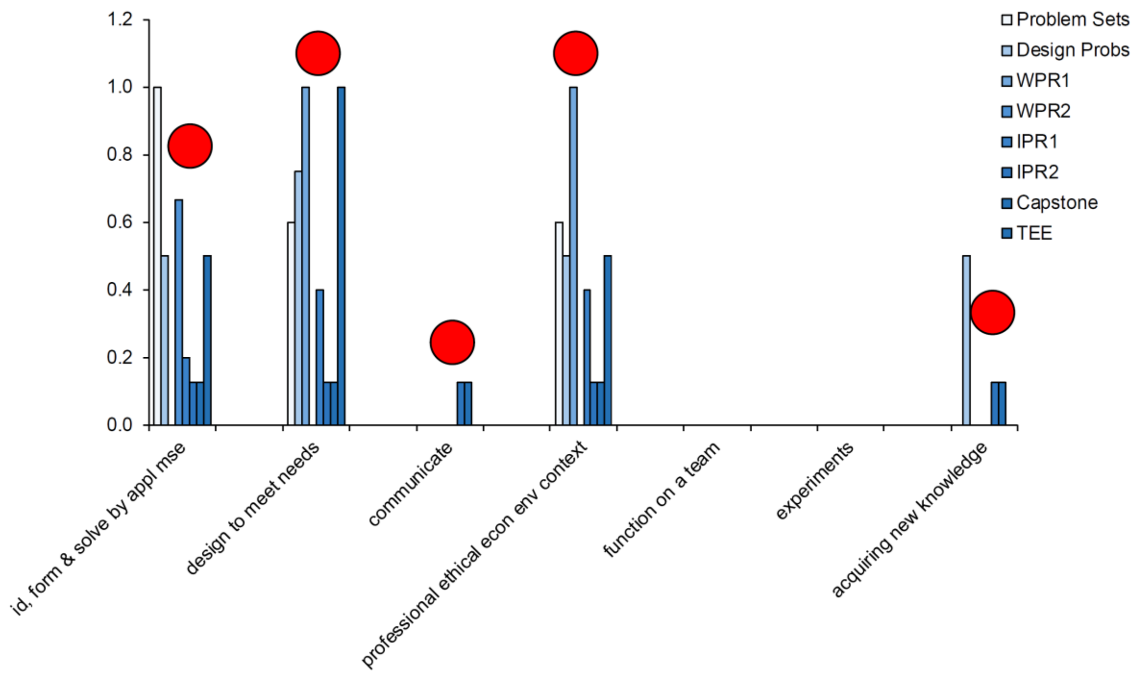


Figure 4-4. Bar chart showing coverage frequencies of student outcomes in in CH402 Chemical Engineering Process Design. WPRs are written partial reviews (exams), IPRs are In-Progress Reviews (progress reports), and the TEE is a Term-End Exam.

Low coverage averages in Figure 4-**4** should not be negatively interpreted and could be strong embedded indicators. For example, two bars are shown for "communicate." The legend indicates that these values come from grades in IPR2 and the capstone report. The coverage frequency values of 0.1 (rounded from 0.125) result from single rubric-based scores that were carried forward to the outcomes assessment worksheet. These single scores, in turn, resulted from two separate rubrics in the course that were averaged together to produce a unique, unambiguous communication score. Since the rubrics delineate specific communication skills associated with student outcome 3, this is a strong embedded indicator.

Once the embedded indicators are identified, the next step in the process is to enter the grades for each graded event into the coverage worksheet. This part of the process is illustrated in Figure 4-**5**, which is screenshot of an enlarged part of the worksheet in Figure

4-**1**. Note that the average grades are shown in bold-faced font along the bottom. For example, Problem Set 1 (PS1) has an average grade of 99%.

Coverage **Student Outcomes** (Outcomes are abbreviated)	PS1 - PIPING	PS2 - PIPE SYS	PS3 - TANKS, C	PS4 - HT TX CC	PS5 - HT EXCH	PS6 - I/O ANAL	PS7 - COSTING	PS8 - COSTING	PS9 - DSPFWF	PS10 - ECON	PS TOT	DP1 - PIPING	DP2 - EXCH DE	DP3 - PROC DE	DP4 - BREAKE\	DP TOT
On completion of the program, our students have demonstrated that they can:	PS = Problem Set; DP = Design Problem															
id, form & solve by appl mse	1	1	1	1	1	1	1	1	1	1	1.0	1	0	0	1	0.5
design to meet needs	1	1	1	1	1	1	0	0	0	0	0.6	1	1	1	0	0.8
communicate	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0
professional ethical econ env context	0	0	0	0	1	1	1	1	1	1	0.6	0	1	1	0	0.5
function on a team	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0
experiments	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0
acquiring new knowledge	0	0	0	0	0	0	0	0	0	0	0.0	0	0	1	1	0.5
Raw Grade Data																
Average	**99**	**92**	**90**	**94**	**73**	**85**	**97**	**90**	**86**	**96**		**92**	**96**	**96**	**97**	

Figure 4-5. Expanded view of Figure 4-1 showing entry of grades. The horizontal lines indicate that the intervening rows in figure 4-1 (for Student Outcome 8 and course objectives) are hidden in this figure.

A second worksheet, called "performance," is shown in Figure 4-**2**. This worksheet runs in tandem with "coverage" and is identical in general layout, with outcomes along the left column and graded events along the top row. The performance worksheet maps grades into the coverage worksheet. The mapping multiplies each 1 or 0 in the outcomes worksheet with the grade corresponding to that event. The result is that each row (corresponding to each outcome) contains a list of grades and zeros. By averaging the *nonzero* entries corresponding to each outcome, we obtain an average measure of performance on those graded events that contributed to the assessment of that outcome. Separate scores are computed for each type of graded event (projects, homework problems, exam questions, etc.), and the results are presented in graphical form.

An example of this part of the process is illustrated in Figure 4-**5**, where the rows corresponding to the student outcomes are shown along with the associated grades. In this example, the students' ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics was measured ten times in the problem sets (PS1-10) and twice in the design problems (DP1 and 4). The resulting averages of the corresponding grades are shown in the gray columns under "PS TOT" and "DP TOT," which stand for "problem set total" and "design problem total." In this case, the average performance measurements were 90% and 95%, respectively. The interpretation of these number in terms of an expected level of attainment is addressed later in this section for each outcome. This assessment process is performed every time the course is given. The results are documented in the course assessment packets, which are maintained by the department in an electronic archive in a shared directory.

Performance

Student Outcomes

(Outcomes are abbreviated)

PS = Problem Set; DP = Design Problem

On completion of the program, our students have demonstrated that they can:

Student Outcomes	PS1 - PIPING	PS2 - PIPE SYS	PS3 - TANKS, C	PS4 - HT TX CC	PS5 - HT EXCH	PS6 - I/O ANAL	PS7 - COSTING	PS8 - COSTING	PS9 - DSPFWF	PS10 - ECON	PS TOT	DP1 - PIPING	DP2 - EXCH DE	DP3 - PROC DE	DP4 - BREAKE\	DP TOT
id, form & solve by appl mse	99	92	90	94	73	85	97	90	86	96	90	92	0	0	97	95
design to meet needs	99	92	90	94	73	85	0	0	0	0	89	92	96	96	0	95
communicate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
professional ethical econ env context	0	0	0	0	73	85	97	90	86	96	88	0	96	96	0	96
function on a team	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
experiments	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
new knowledge	0	0	0	0	0	0	0	0	0	0	0	0	0	96	97	97

Figure 4-6. Expanded view of the upper left portion of Figure 4-2 showing automatic movement of grades moved into the performance worksheet.

An example of the roll-up of the performance worksheet is shown graphically in Figure 4-**7**. As before, this is only one example from one course, and the details in the figure differ for each course as each CD customizes his or her analysis. The plot shows how the students performed on the graded events and how those graded events relate to the student outcomes. For example, the design outcome has performance of greater than 67% in all seven of the different types of graded events in which it was assessed. As with Figure 4-**4**, the specific type and location of coverage is designated in the "outcomes" worksheet. Also, as before, the red circles designate student outcomes that the CD must cover in this course in order to ensure overall coverage of the student outcomes in the program. The required level of performance in this case is 67% and this is indicated in Figure 4-**7** with a horizontal dashed line. Finally, the percentages in each of the gray columns in Figure 4-**2** are averaged together, placed on a 0-5 scale, and carried forward to the program-level assessment.

Mechanical Engineering Coursework Embedded Indicators

Two of the required courses in the chemical engineering program are managed by the Mechanical Engineering Program, including MC311 and MC312 Thermo-Fluids I and II. These courses are used by the mechanical engineering program to assess student outcomes 1, 3, 5, 6, and 7 using rubrics for direct assessment of embedded indicators. Since the mechanical engineering student outcomes are identical to chemical engineering, we can make direct use of this data in assessing the chemical engineering program. Data for chemical engineering students is aggregated separately by the mechanical engineering program and sent to us for use in our assessment process. In the plots below, mechanical engineering embedded indicator scores are reported twice and will appear for example as 3.71 / 3.91. The first number is the aggregate for chemical engineering students only, and the second is the course-wide aggregate score for comparison.

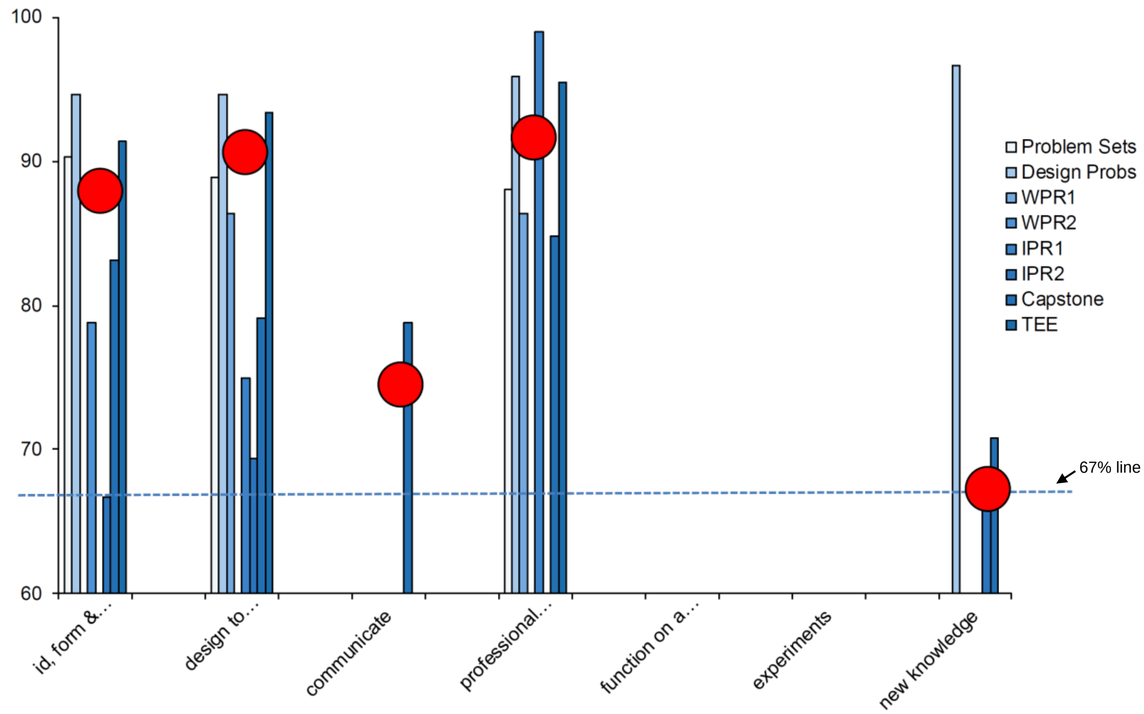


Figure 4-7. Chart showing performance on student outcomes in CH402 Chemical Engineering Process Design. Similar charts are generated for each department course used for outcomes assessment. WPRs are written partial reviews (exams), IPRs are In-Progress Reviews (progress reports), and the TEE is a Term-End Exam.

End-of-Semester Student Surveys

The program solicits feedback from graduating Chemical Engineering students on their perceived level of achievement of the Chemical Engineering Student Outcomes at the end of each semester. This survey is designed to encourage the students to reflect on the courses in which they are currently enrolled and the degree to which the course contributed to the outcomes. The survey asks the students to rate the course's impact on their ability to perform the outcome. The results of the survey are included in the program assessment data pack (discussed below), carried forward to the program-level assessment process for review and analysis.

Fundamentals of Engineering Examination (FEE)

Identification, Collection, Preparation, and Evaluation. Students enrolled in the chemical engineering program are encouraged to take the FEE. Specific FEE subjects as well as the percentage of students that take the FEE correspond to our student outcomes and we find them to be useful for program assessment. The exam is taken by our students in late March or early April and graded by the National Council of Examiners for

Engineering and Surveying (NCEES). Once the exam scores are finalized, the NCEES provides a detailed report to the Academic Affairs Division of the Dean's Office at USMA. The Dean's office then forwards this report to the various engineering programs. The report includes the number of students from our program who passed, as well as their performance on the individual topics. The NCEES does not provide individual student results or exam scores, only aggregates. The overall pass rate for the exam as well as the specific subject scores are nationally normed, so the scores are useful to us as assessment metrics. We compare the topic-by-topic results and the overall pass rate to the national averages (using the national averages as performance targets) for program-level assessment.

Chemical Engineering Program Exit Survey

The program solicits feedback from graduating Chemical Engineering students on their perceived level of achievement of the Chemical Engineering Student Outcomes. The program has developed a survey that allows the students to rate their own level of achievement with respect to each of the eight student outcomes. The survey is administered at the end of the final semester, and results are included in the annual report.

Cadet Character Education Program

Training in honor and ethics takes place as part of the Cadet Character Education Program (CCEP) during the academic year and during summer military instruction. All cadets are required to complete this program. While this program does not specifically address engineering ethics and professional responsibilities, it does address those features for professional officers, and there is considerable overlap. Concepts of honorable and ethical living are reinforced in the cadet, contributing to the whole person and setting the tone for the development of specific variations in engineering. The program is overseen by the Commandant of Cadets through the Simon Center for the Professional Military Ethic. CCEP customizes instruction to each of the four year-groups of cadets, who interact with faculty volunteers who share their perspectives and experience in the Armed Forces, with industry, and at other civilian institutions. Specifics of the program can be viewed at the Simon Center web site at https://westpoint.edu/military/simon-center-for-the-professional-military-ethic.

Teamwork Skills Rubric

The teamwork skills rubric (**Figure 4-18**, page 4-25) was designed to assess achievement of Student Outcome 5 (ABET 5). This outcome requires students to have an ability to function effectively on a team. The rubric contains skills that collectively define this ability. These skills are listed in the rows of the rubric. The columns correspond to average levels of achievement of the skills. The skills include technical competence, communication, organization, and teamwork, and were agreed on by the course director and the program assessment coordinator. The levels of achievement in the rubric contain short descriptions of typical attributes at the various levels to assist the user in assigning a score. The rubric is flexible in the sense that the rubric elements can be easily altered if we determine that different skills or attributes are relevant.

The rubric is given to the students in CH459 Chemical Engineering Laboratory at the end of each of the six projects in the course. Each project is composed of a team leader and team members. The rubric is completed twice by the team leader, once as a self-assessment and once for each of his or her team members. For a typical group size of four, each cadet has two opportunities to be team leader and therefore has this duty twice. The rubric also has a space for comments so that the students can comment on any skills or aspects of teamwork that are not included in the rubric. Using the results, the instructor verbally counsels the team leader at the end of each project with a focus on lessons learned and self-improvement. The program director uses the average scores to assess program-level performance to look for areas that might require program-level improvements. An example of the program director's roll-up is shown on page 4-23.

Lifelong Learning Skills Rubric

The lifelong learning skills rubric (page 4-28), was originally designed to assess performance in the old ABET student outcome i (recognizing the need and developing the skills required for life-long learning) and was used for that outcome until AY2018. The rubric elements are also relevant for new ABET student outcome 7 (acquiring new knowledge). They are: (1) engagement in pre-professional activities, (2) recognition of skills, (3) recognition of intellectual growth, and (4) the ability to communicate these features to other professionals. The rubric was applied to resume writing assignments in CH365. The resume was written at the beginning of the semester, then revised at the end, with the expectation that students could identify new skills or professional attributes that they acquired during the interim. Details of the performance are shown on page 4-28.

Contemporary Issues Rubric

The contemporary issues rubric (pages 4-32 to 4-33) was originally developed to assess old ABET student outcome k (demonstrating knowledge of contemporary issues) and was used to assess that outcome until AY2018. However, the rubric incorporates skills associated with acquiring new knowledge (new ABET student outcome 7). The rubric has been re-designed for AY20 to track the new outcome more closely, but for AY19, we used the old version to assess new student outcome 7. The four skills articulated in the rubric are (1) determining whether the issue is contemporary, (2) technical competence, (3) synthesis of ideas, and (4) communication. The rubric was applied to resume writing assignments in CH485. In this case, LTC Miller used two writing assignments, the first being an initial draft and the second a final draft. A third application was also used for students desiring additional feedback. The results are summarized on the pages 4-32 and 4-33, using the actual rubric to format the results, with cadet average scores shown for each rubric item.

Course Grades

This assessment is limited to those courses where there is correlation between the course topic and a student outcome. This happens specifically in student outcome 8, which identifies topical areas in the engineering sciences. For example, student outcome 8 states that graduates of our program understand chemistry (specifically organic chemistry). In this case, course grades in the organic chemistry course provide a measure of performance for this outcome. The grades are collected from the student transcripts and translated into a numerical equivalent using the quality point scale shown on page 1-6. The average grade is computed from the individual student grades, and the grades are summarized by course. For cases where more than one course that covers the same outcome, the average is calculated over the multiple courses. We then use a running average over five years as a baseline for comparison to identify areas where we may need improvement.

Overall Process

A complete set of assessment data for one assessment cycle is shown on pages 4-15 to 4-36. After the data has been compiled, it is sent to the faculty and to the advisory board for review and discussion. To facilitate discussion, documentation, and reporting, we capture the opinions of these groups using a survey that allows respondents to rate the achievement of the individual outcomes. The survey responses are then averaged and compiled into tables for the annual program report. Examples are shown in **Table 4-5** and **Table 4-6** on pages 4-37 and 4-38. The program director reviews the data from assessment instruments, including the input from faculty and advisory board assessments, to determine the extent to which the student outcomes are being achieved, and then provides an overall score based on the data and the input from the faculty and advisory board. A sample of this summary is shown in **Table 4-7** on page 4-39. The survey scores are generally high, indicating that most faculty and board members feel we are achieving the outcomes. Even though these assessment scores tend to be high, year-to-year trends help us identify any areas where we might need improvement. Several examples of this type of assessment-based effort are provided in Section B starting on page 4-40. The data shown in the self-study are excerpts from cases that have been used to improve specific items. The excerpts come from an extensive collection of data that is documented and maintained in our annual program reports. These reports are archived in a SharePoint directory maintained by the Dean's office.

THIS PAGE INTENTIONALLY LEFT BLANK

Level of Achievement of Student Outcome 1:

On completion of the chemical engineering program, our graduates will be able to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Assessment Instruments Used and Frequency of Use:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. Fundamentals of Engineering Examination, once/yr.
3. End-of-Semester Student Surveys, once/semester.
4. Chemical Engineering Program Exit Survey, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

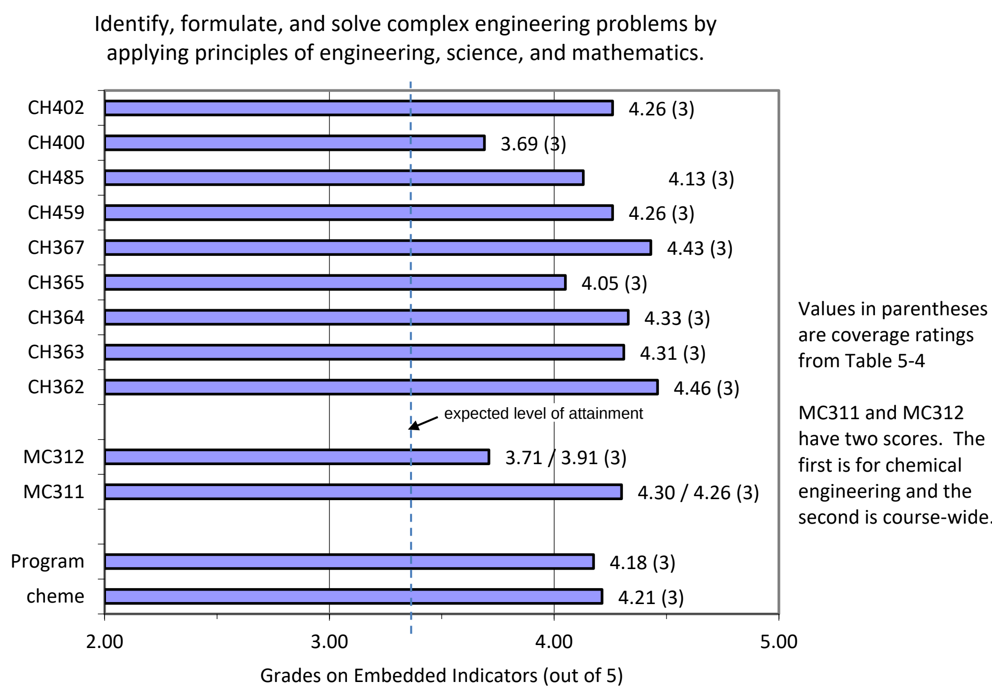


Figure 4-8. Performance on embedded indicators for student outcome 1.

2. Fundamentals of Engineering Examination (FEE). According to the 2019 report from NCEES, 21 out of 24, or 87.5% of the students in the Class of 2019 took and passed the FE Exam. Three who failed took the exam again and passed on the second attempt (100% pass rate). The national average in 2019 was 77%, and this is our expected level of attainment. In the previous five years, the pass rates were 81% in 2018, 94% in 2017, 79% in 2016, 76% in 2015, and 92% in 2014. Our running average over those five years is 84.8% ± 8% (81% ± 5% for the national).

Note: The national percentage of chemical engineering examinees passing was 86% for many years prior to 2015. However, as of that year, NCEES changed our comparator group from all takers to those first-time takers taking the exam within 12 months of graduation. Also, a new chemical engineering exam in electronic format was implemented that year. As a result of these changes, the national average dropped to 77% (74% this year). That is, we are **above** the national average, and the national average is our expected level of attainment.

3. End of Semester Student Surveys

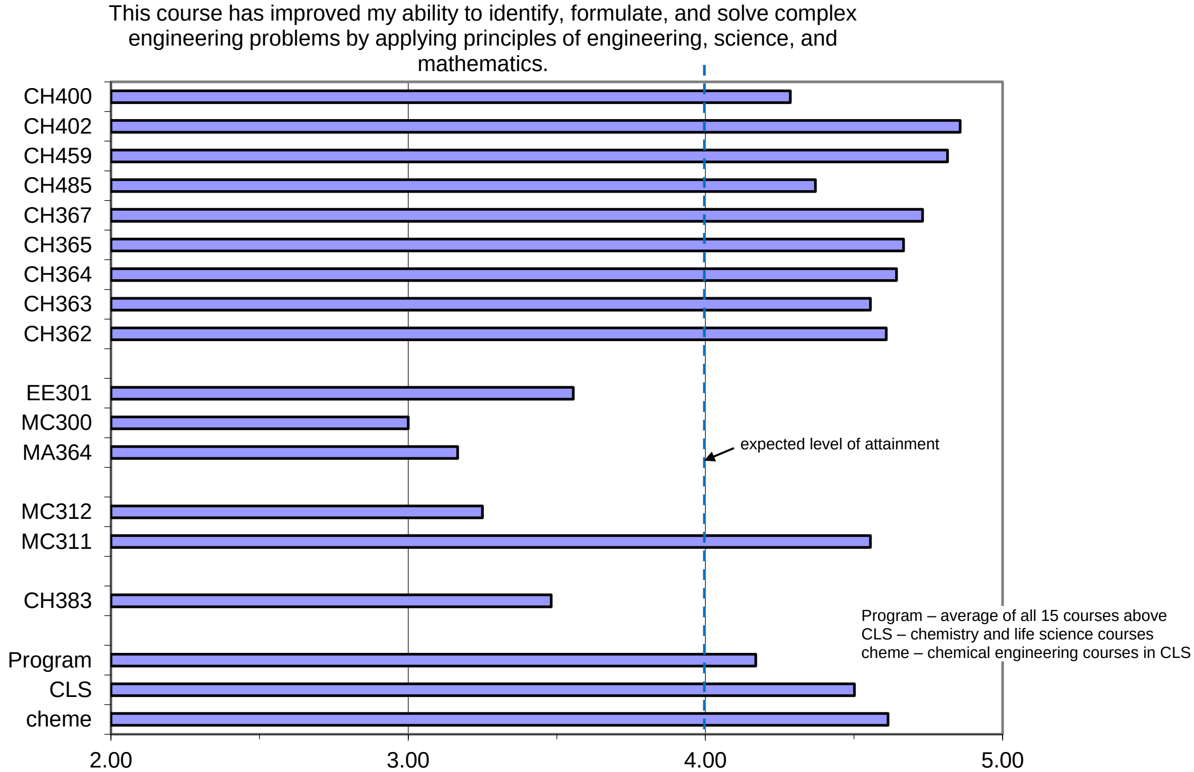


Figure 4-9. End-of-semester student survey responses for student outcome 1.

4. Chemical Engineering Program Exit Survey. This survey is issued to the Firsties at the end of their last semester. In this question, they were asked whether they agree with the statement "The program has prepared me to Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics." 21 out of 21 cadets completed the survey. All 21 of the cadets said that they either agreed or strongly agreed, and 18/21 replied that they strongly agreed (score = 5/5). This equates to a mean score of 4.857/5.00 for the 21 cadets. The expected level of attainment on this survey is 4.00/5.00.

Level of Achievement of Student Outcome 2:

On completion of the chemical engineering program, our graduates will be able to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. End of Semester Student Surveys, once/semester.
3. Course Grades in CH402 Chemical Engineering Process Design, once/yr.
4. Chemical Engineering Program Exit Survey, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

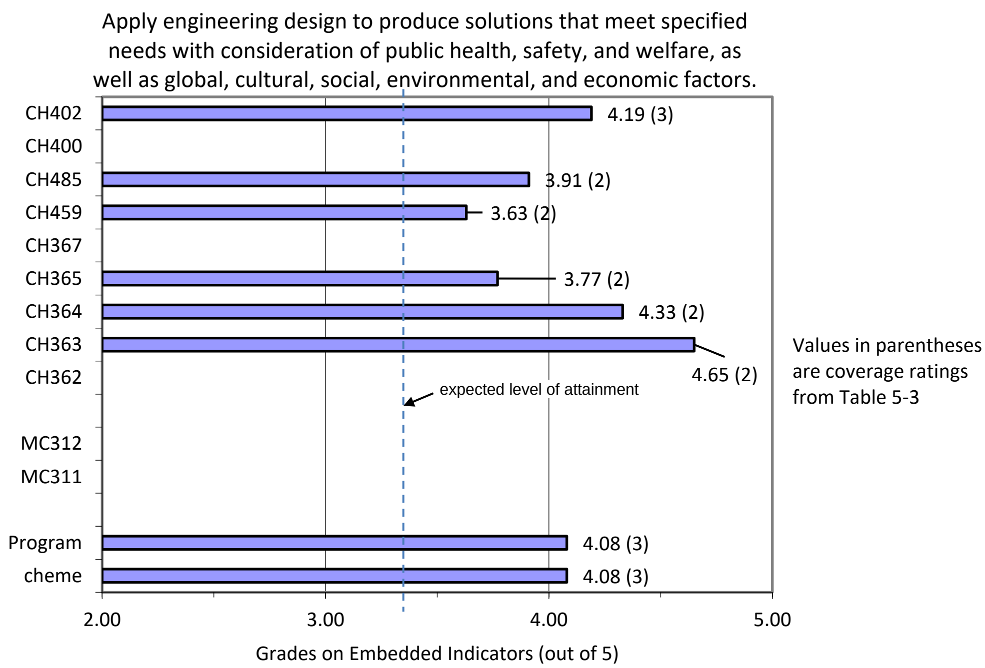


Figure 4-10. Performance on embedded indicators for student outcome 2.

2. End of Semester Student Surveys

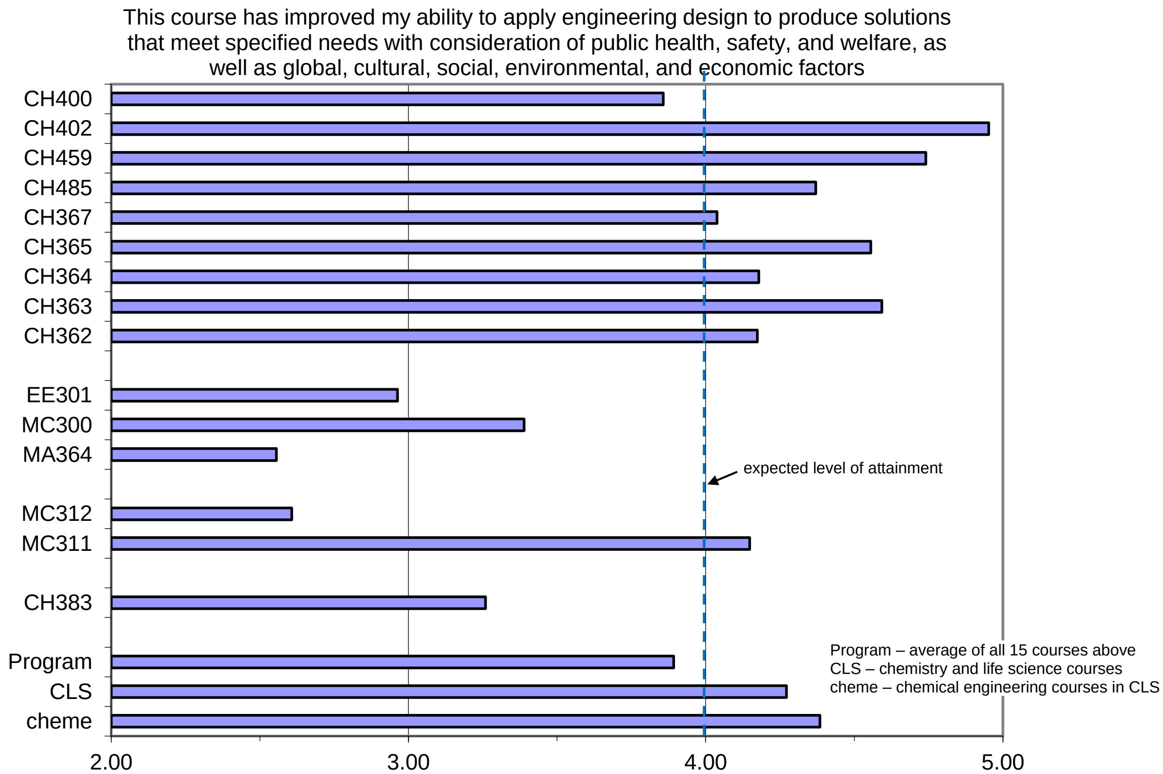


Figure 4-11. End-of-semester student survey responses for student outcome 2.

3. The average course grade in CH402 Chemical Engineering Process Design was 3.27±0.92 (n=21) in AY19, compared to 3.37±0.66 (n=19) in AY18, 2.73±0.39 (n=16) in AY17, 3.43±0.49 (n=24) in AY16, and 3.40±0.75 (n=20) in AY15, 3.23±0.71 (n=13) for AY14. *The 5-year running average for the previous five years is 3.23, and this is our expected level of attainment. This year's score was slightly above the 5-year running average.*

4. Chemical Engineering Program Exit Survey. As stated earlier, this survey is given to the Firsties at the end of their last semester. In this question, they were asked whether or not they agree with the statement "The program has prepared me to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors." 21 out of 21 cadets completed the survey. All 21 cadets said that they either agreed or strongly agreed, and 17/21 replied that they strongly agreed (score = 5/5). This equates to a mean score of 4.810/5.00 for the 21 cadets. The expected level of attainment on this survey is 4.00/5.00.

Level of Achievement of Student Outcome 3:

On completion of the chemical engineering program, our graduates will be able to communicate effectively with a range of audiences.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. End of Semester Student Surveys, once/semester.
3. Course Grades in CH459 Unit Operations Laboratory, once/yr.
4. Chemical Engineering Program Exit Survey, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

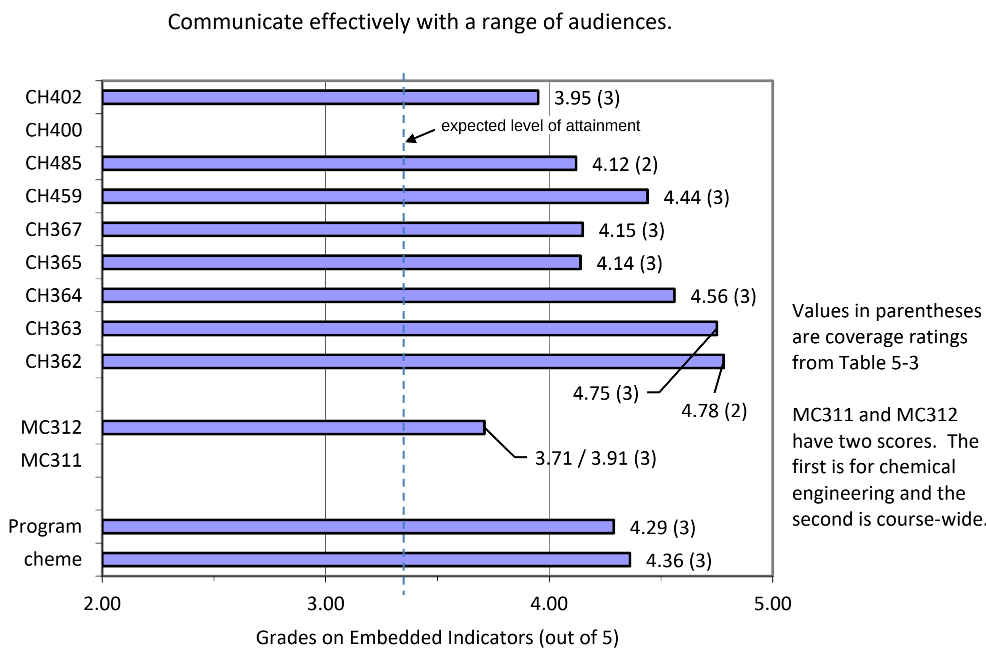


Figure 4-12. Performance on embedded indicators for student outcome 3.

2. End of Semester Student Surveys

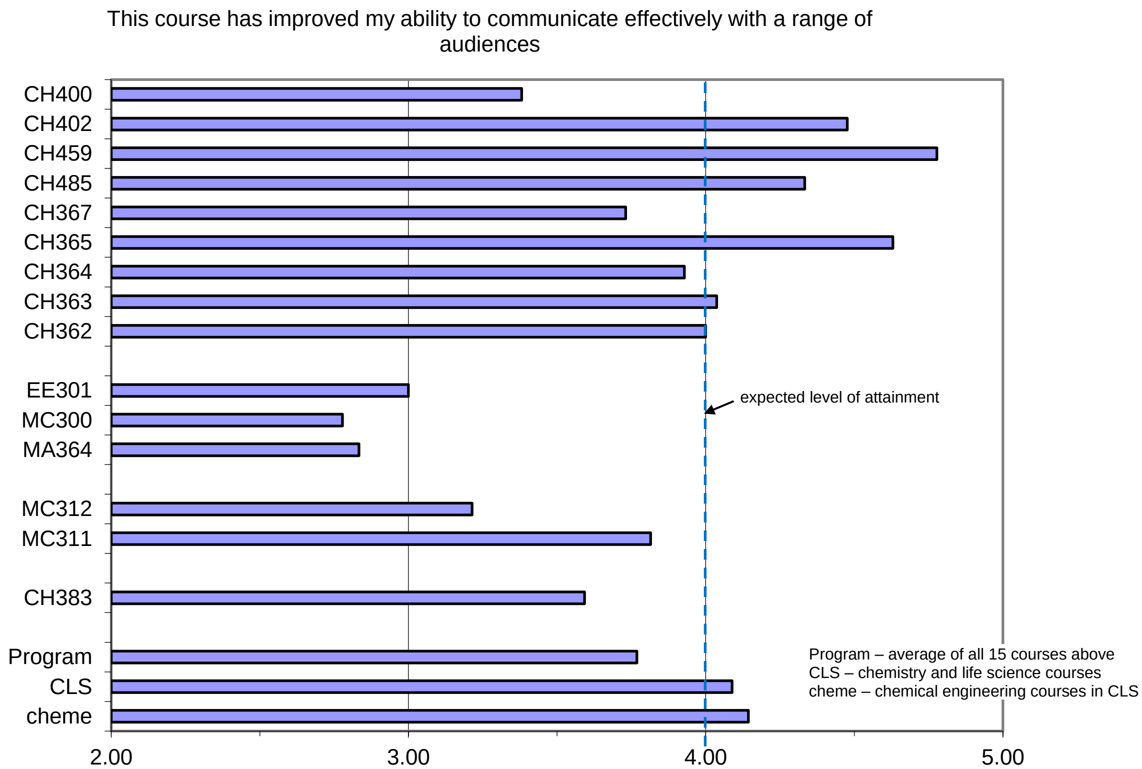


Figure 4- 13. End-of-semester student survey responses for student outcome 3.

3. The average course grade in CH459 Chemical Engineering Laboratory was 3.52±0.44 (n=21) in AY19, compared to 3.42±0.64 (n=19) in AY18, 3.54±0.30 (n=16) in AY17, 3.70±0.35 (n=23) in AY16, 3.67±0.37 (n=20) in AY15, and 3.87±0.44 (n=13) in AY14. *The 5-year running average is 3.6, and this is our expected level of attainment. This year's score was 0.08 points below the 5-year running average, which is low but improved over the previous year.*
4. Chemical Engineering Program Exit Survey. As stated earlier, this survey is given to the Firsties at the end of their last semester. In this question, they were asked whether they agree with the statement "The program has prepared me to communicate effectively with a range of audiences." 21 out of 21 cadets completed the survey. All 21 cadets said that they either agreed or strongly agreed, and 15/21 replied that they strongly agreed (score = 5/5). This equates to a mean score of 4.714/5.00 for the 21 cadets. The expected level of attainment on this survey is 4.00/5.00.

Level of Achievement of Student Outcome 4:

On completion of the chemical engineering program, our graduates will be able to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. Fundamentals of Engineering Examination Performance Index, once/yr.
3. End of Semester Student Surveys, once/semester.
4. Chemical Engineering Program Exit Survey, once/yr.
5. Completion of Cadet Character Education Program, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

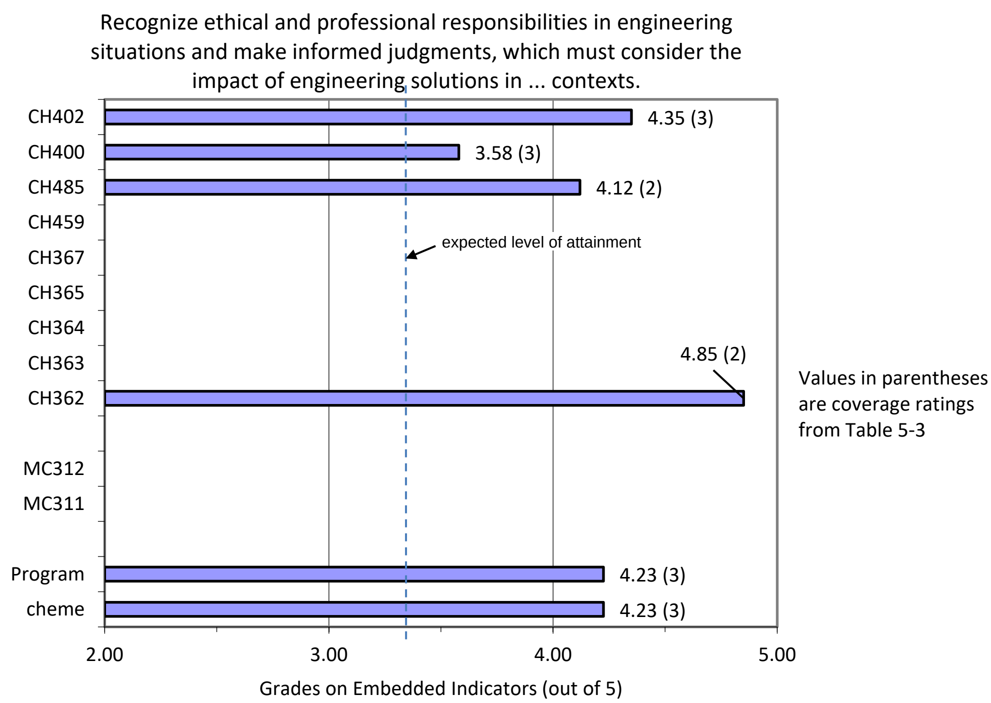


Figure 4-14. Performance on embedded indicators for student outcome 4.

2. Fundamentals of Engineering Examination Performance.

Table 4-2. Fundamentals of Engineering Exam topic performance in ethics and professional practice and process design and economics.

Subject	Outcome	Questions	USMA	National (expected level of attainment)
Ethics and Professional Practice	6	2	13.7	11.8
Process Design and Economics	8	8	10.6	9.7

The national average performance index was 11.8 ± 5 in ethics and professional practice and 9.7 ± 2.6 in process design and economics, and these are our expected levels of attainment, where the uncertainties are standard deviations.

3. End of Semester Student Surveys

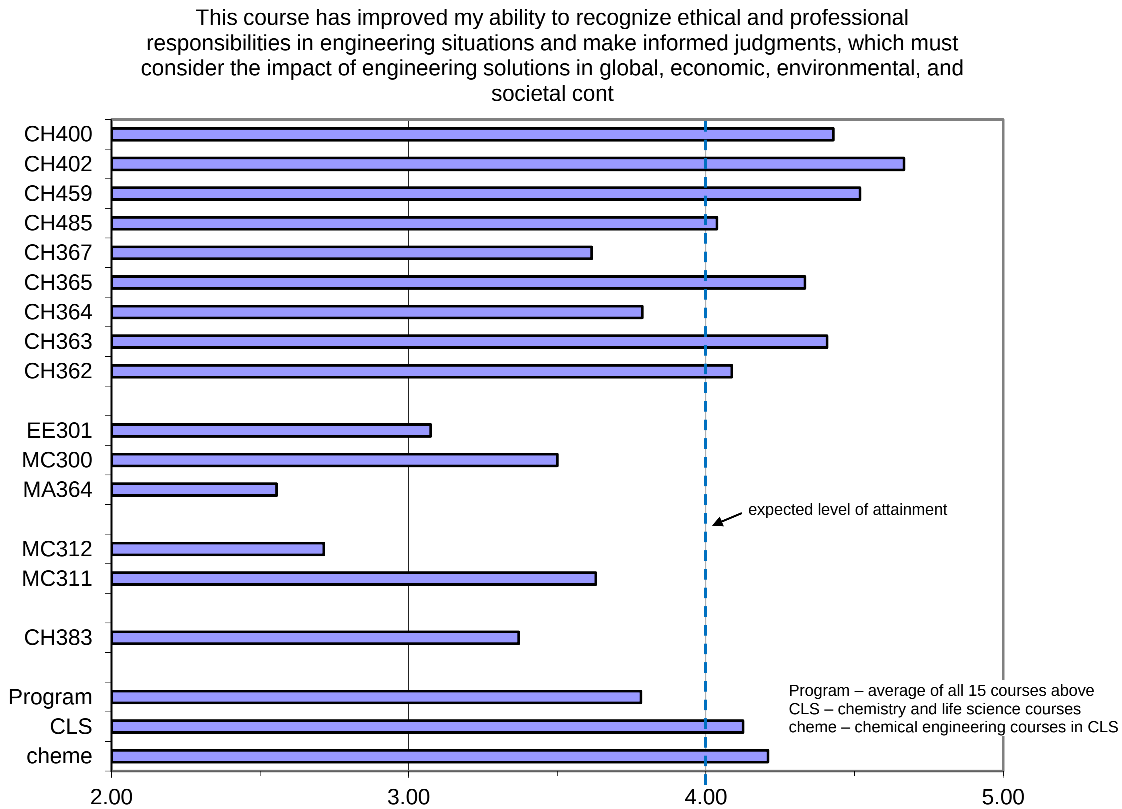


Figure 4-15. End-of-semester student survey responses for student outcome 4.

4. Chemical Engineering Program Exit Survey. This survey is given to the Firsties at the end of their last semester. In this question, they were asked whether or not they agree with the statement "The program has prepared me to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts." 21 out of 21 cadets completed the survey, all 21 said they either agreed or strongly agreed, and 12/21 replied that they strongly agreed (score = 5/5). This equates to a mean score of 4.571/5.00 for the 21 cadets. The expected level of attainment on this survey is 4.00/5.00.

5. Training in honor and ethics takes place as part of the Cadet Character Education Program (CCEP). All 21 chemical engineering cadets in the class of 2019 successfully completed the 4-year Professional Military Ethics Education program.

.

Level of Achievement of Student Outcome 5:

On completion of the chemical engineering program, our graduates will be able to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. End of Semester Student Surveys, once/semester.
3. Chemical Engineering Program Exit Survey, once/yr.
4. Multidisciplinary Skills Rubric, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

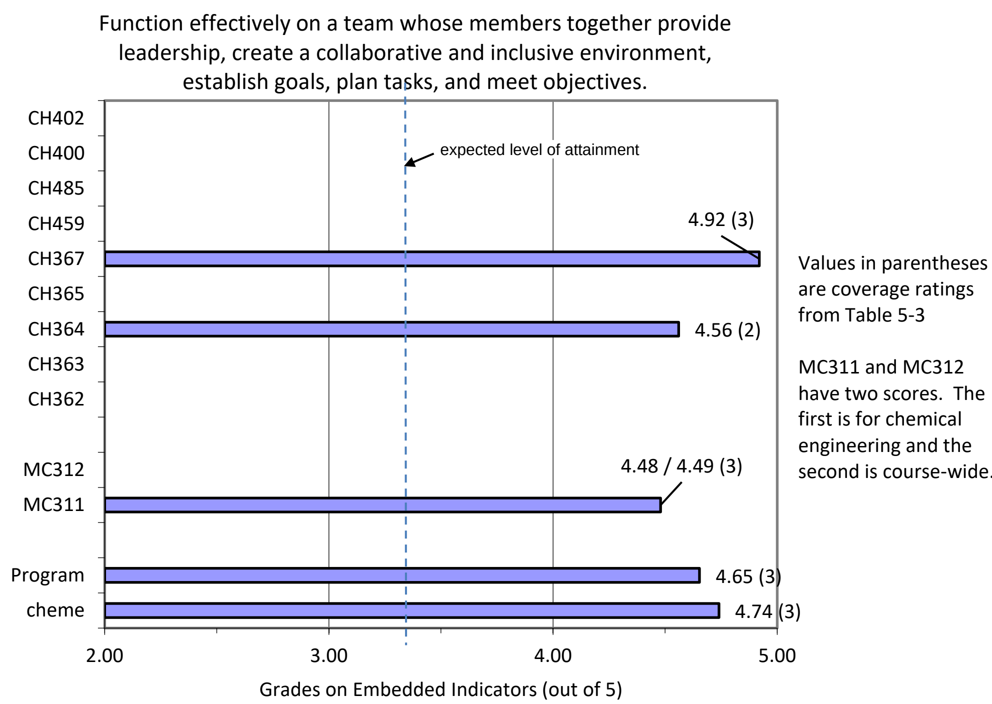


Figure 4-16. Performance on embedded indicators for student outcome 5.

2. End of Semester Student Surveys

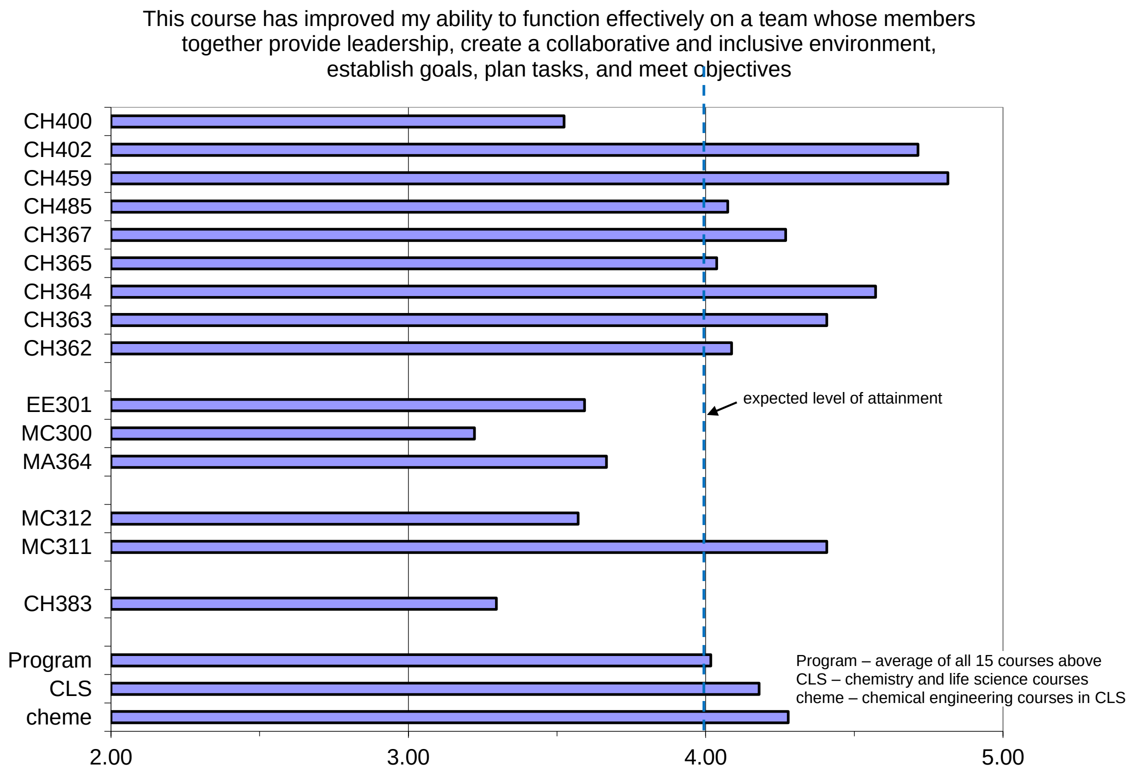


Figure 4-17. End-of-semester student survey responses for student outcome 5.

3. Chemical Engineering Program Exit Survey. As stated earlier, this survey is given to the Firsties at the end of their last semester. In this question, they were asked whether or not they agree with the statement "The program has prepared me to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives." 21 out of 21 cadets completed the survey. All 21 cadets said that they either agreed or strongly agreed, and 15/21 replied that they strongly agreed (score = 5/5). This equates to a mean score of 4.714/5.00 for the 21 cadets. The expected level of attainment on this survey is 4.00/5.00.

4. Teamwork Skills Rubric. The rubrics are completed by the cadets after each laboratory exercise in CH459. Averages from all groups for round robins 1 and 2 are shown in **Figure 4-18**. Superscript "a" designates group leader self-assessments (Group Leader Self-Assessment or GLSA). Superscript "b" designates the team leader's assessment of his or her team members (Group Leader Assessment of Team, GLAT). The colors in the rubric indicate the expected level of attainment. The expected level of attainment is 4.0 (green). The results shown here indicate that the cadets are meeting or exceeding expectations in all cases.

Your Name: Armstrong, LTC, Instructor				Person Assessed: **Cadets in CH459**					
Your Position: CH459 CD				Major of Person Assessed: **Chemical Engineering**					
	1 – Needs Improvement	**1**	**2**	**3 – Meets Expectations**	**3**	**4**	**5 – Exceeds Expectations**	**5**	**N/A**
Technical Competence	**Some misunderstandings of the technical content.**			Demonstrated knowledge of the technical content.		**4.4[a] ±.2[c]**	Exceptional knowledge of technical content.	**4.7[b] ±.3[c]**	
Communication	**Lacked sensitivity and/or did not provide specific suggestions for improvement.**			Effectively communicated important points.			Exceptional ability to explain important points. Very effectively communicated ideas for improvement.	**4.7[a] ±.3[c] 4.7[b] ±.4[c]**	
Organization	**Was not prepared or did not give sufficient time to prepare.**			Demonstrated effective organization during class.		**4.5[a] ±1.0[c]**	Was exceptionally efficient, timely and responsive throughout the entire process.	**4.8[b] ±.3[c]**	
Teamwork	**Demonstrated limited ability to see other perspectives or find common ground.**			Worked collaboratively with team members to reach consensus.			Exceptional ability to help group find common ground or resolve conflict in order to ultimately reach consensus.	**4.7[a] ±.5[c] 4.8[b] ±.4[c]**	
Are the cadets capable of functioning on multidisciplinary teams? **Yes**	**Comments: Each cadet was group leader twice. Footnote "a" designates the average of all Group Leader Self-Assessment (GLSA) scores, while "b" designates average of all Group Leader Assessment (GLAT) scores. Footnote "c" designates standard deviations.**						Assignment used for assessment: **AY19, Round Robin 1**		

Your Name: Armstrong, LTC, Instructor				Person Assessed: **Cadets in CH459**					
Your Position: CH459 CD				Major of Person Assessed: **Chemical Engineering**					
	1 – Needs Improvement	**1**	**2**	**3 – Meets Expectations**	**3**	**4**	**5 – Exceeds Expectations**	**5**	**N/A**
Technical Competence	**Some misunderstandings of the technical content.**			Demonstrated knowledge of the technical content.			Exceptional knowledge of technical content.	**4.7[a] ±.7[c] 4.8[b] ±.3[c]**	
Communication	**Lacked sensitivity and/or did not provide specific suggestions for improvement.**			Effectively communicated important points.			Exceptional ability to explain important points. Very effectively communicated ideas for improvement.	**4.8[a] ±.0[c] 4.8[b] ±.3[c]**	
Organization	**Was not prepared or did not give sufficient time to prepare.**			Demonstrated effective organization during class.			Was exceptionally efficient, timely and responsive throughout the entire process.	**4.8[a] ±.8[c] 4.8[b] ±.3[c]**	
Teamwork	**Demonstrated limited ability to see other perspectives or find common ground.**			Worked collaboratively with team members to reach consensus.			Exceptional ability to help group find common ground or resolve conflict in order to ultimately reach consensus.	**4.8[a] ±.0[c] 4.8[b] ±.3[c]**	
Are the cadets capable of functioning on multidisciplinary teams? **Yes**	**Comments: Each cadet was group leader twice. Footnote "a" designates the average of all Group Leader Self-Assessment (GLSA) scores, while "b" designates average of all Group Leader Assessment (GLAT) scores. Footnote "c" designates standard deviations.**						Assignment used for assessment: **AY19, Round Robin 2**		

Figure 4-18. Teamwork skills rubric with average data from cadet assessments from the six senior lab projects. Part (a) shows the results from project round robin 1, and part (b) for round robin 2.

THIS PAGE INTENTIONALLY LEFT BLANK

Level of Achievement of Student Outcome 6:

On completion of the chemical engineering program, our graduates will be able to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. End-of-Semester Student Surveys, once/semester.
3. Chemical Engineering Program Exit Survey, once/yr.
4. Course Grades in CH459 Unit Operations Laboratory, once/yr.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

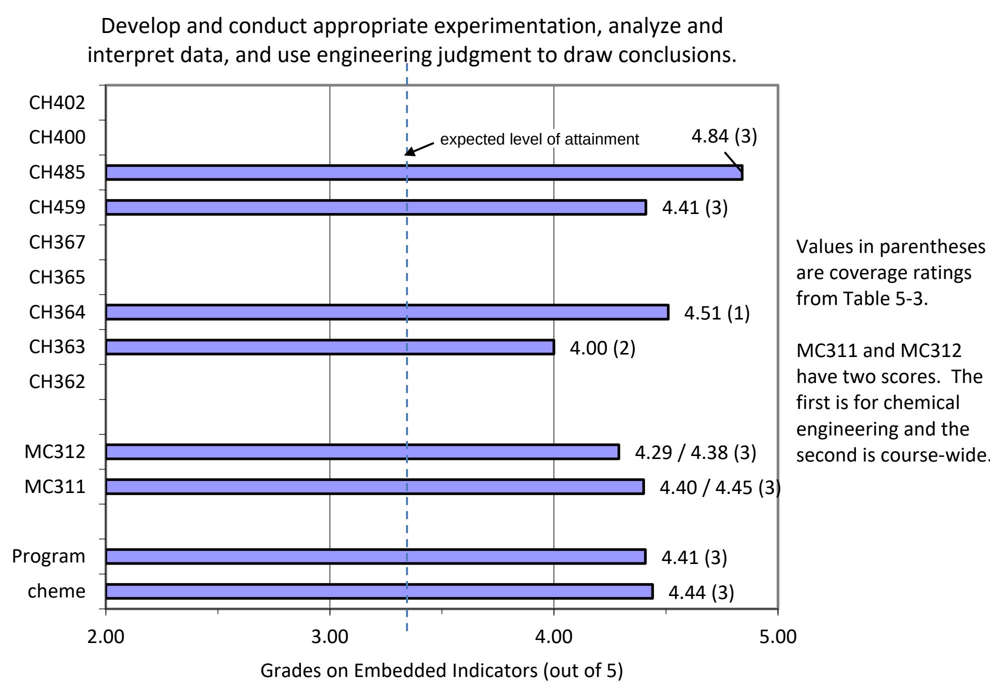


Figure 4-19. Performance on embedded indicators for student outcome 6.

2. End of Semester Student Surveys

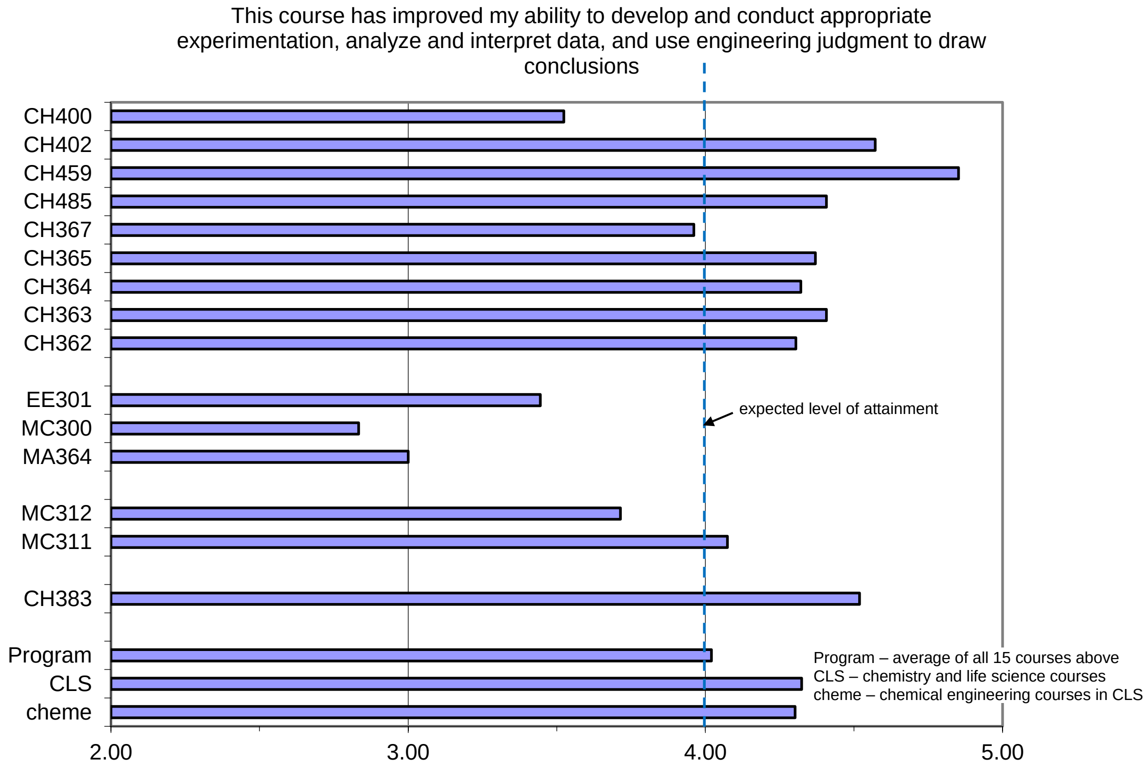


Figure 4-20. End-of-semester student survey responses for student outcome 6.

3. Chemical Engineering Program Exit Survey. As stated earlier, this survey is given to the Firsties at the end of their last semester. In this question, they were asked whether they agree with the statement "The program has prepared me to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions." 21 out of 21 cadets completed the survey. All 21 cadets said that they either agreed or strongly agreed, and 16/21 replied that they strongly agreed (score = 5/5). This equates to a mean score of 4.762/5.00 for the 21 cadets. The expected level of attainment on this survey is 4.00/5.00.

4. The average course grade in CH459 Chemical Engineering Laboratory was 3.52±0.44 (n=21) in AY19, compared to 3.42±0.64 (n=19) in AY18, 3.54±0.30 (n=16) in AY17, 3.70±0.35 (n=23) in AY16, 3.67±0.37 (n=20) in AY15, and 3.87±0.44 (n=13) in AY14. *The 5-year running average is 3.6, and this is our expected level of attainment. This year's score was 0.08 points below the 5-year running average, which is low but improved over the previous year.*

Level of Achievement of Student Outcome 7:

On completion of the chemical engineering program, our graduates will be able to acquire and apply new knowledge as needed, using appropriate learning strategies.

Assessment Instruments and Frequency:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators, once/yr.
2. Percent of eligible students taking the Fundamentals of Engineering Examination (FEE), once/yr.
3. End of Semester Student Surveys, once/semester.
4. Chemical Engineering Program Exit Survey, once/yr.
5. Lifelong Learning Skills Rubric, twice per year.
6. Contemporary Issues Rubric, multiple times per year.

Assessment Results:

1. Chemical & Mechanical Engineering Coursework Embedded Indicators

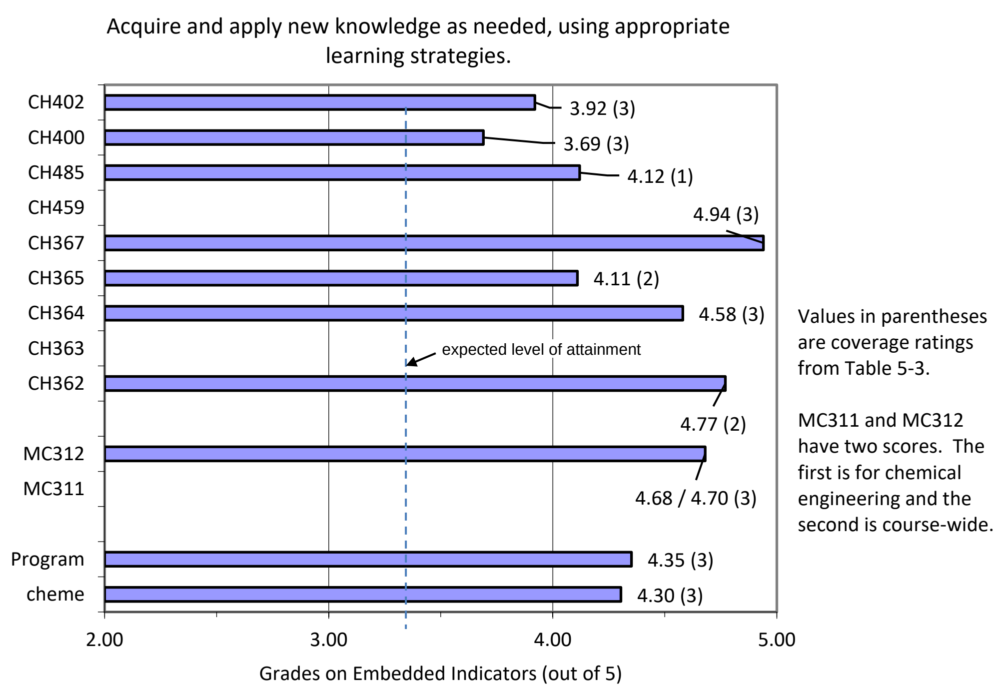


Figure 4-21. Performance on embedded indicators for student outcome 7.

2. Percent of Eligible Cadets taking the Fundamentals of Engineering Examination (FEE). For the Class of 2019, 24 chemical engineering cadets (100% of eligible cadets) prepared for and took the FEE. This compares to 100% in 2018, 100% in 2017, 100% in 2016, 100% in 2015, and 100% in 2014. Since all of our cadets prepare for the exam in CH400, our expected level of attainment is 100%. Additionally, on average, approximately 25% of the graduating chemical engineers nationwide and 93% of the graduating engineers from all disciplines at the USMA take the FEE.

3. End of Semester Student Surveys

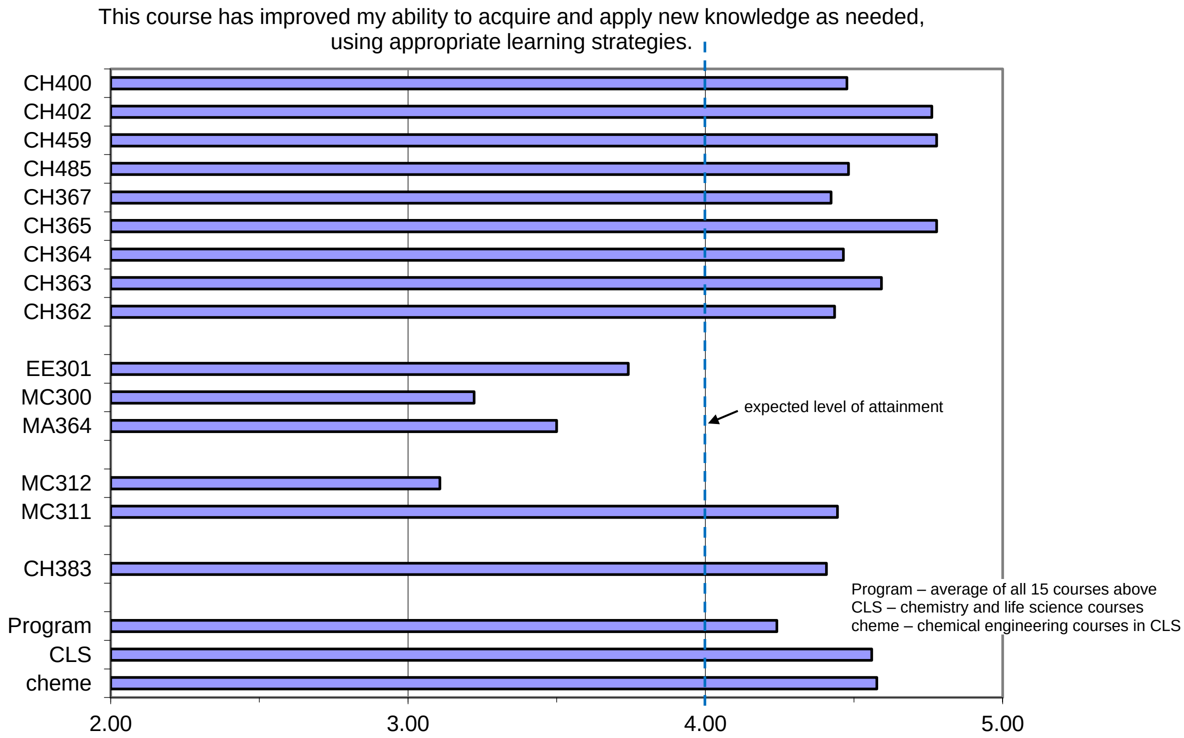


Figure 4-22. End-of-semester student survey responses for student outcome 7.

4. Chemical Engineering Program Exit Survey. As stated earlier, this survey is given to the Firsties at the end of their last semester. In this question, they were asked whether they agree with the statement "The program has prepared me to acquire and apply new knowledge as needed, using appropriate learning strategies." 21 out of 21 cadets completed the survey. All 21 cadets said that they either agreed or strongly agreed, and 19/21 replied that they strongly agreed (score = 5/5). This equates to a mean score of 4.905/5.00 for the 21 cadets. The expected level of attainment is 4.00/5.00.

5. Lifelong Learning Skills Rubric. The lifelong learning skills rubric is described on page 4-12. The rubrics are shown in data in **Figure 4-23** for writing assignments 1 and 2 in CH365 (resume and revision). The resume was written at the beginning of the semester, then revised at the end. The average scores are shown in the rubric. The levels of attainment are color-coded, with red indicating a need for improvement, yellow indicating acceptable performance, and green indicating that expectations are met or exceeded. Instructor comments are also shown in the rubrics. Cadets were all in the green after the second assignment.

(a)

Your Name: **Professor Biaglow**	Cadet Assessed: **Program-level (all cadets in CH365)**
Your Position: **Instructor, CH365**	Major of Cadet Assessed: **Chemical Engineering**

	1 – Needs Improvement	**1**	**2**	**3 – Meets Expectations**	**3**	**4**	**5 – Exceeds Expectations**	**5**	**N/A**
Engagement	No evidence of pre-professional activities.			References pre-professional activities are lacking or connections to chemical engineering are weak or implied.		**4.1 ±.8**	Uses examples of pre-professional chemical engineering activities.		
Recognition	Skills learned in chemical engineering courses taken in previous semesters are not listed.			Skills are listed, but the skills are vaguely described, or connection to chemical engineering concepts is not clear.			Identifies specific skills learned in chemical engineering courses.	**4.6 ±.6**	
Intellectual Growth	Unable to identify new concepts learned this semester.			Changes are apparent in document, but connections to recent activities in chemical engineering are weak or implied.	**3.8 ±1.1**		Addition of multiple skills acquired this semester.		
Communication	Resume lacks organization or cohesion. Numerous grammatical errors that may interfere with meaning. Target audience unclear.			Occasional grammar errors that do not impede meaning. Demonstrates ability to write a basic resume, but document is uninteresting and flat.	**3.9 ±1.0**		Demonstrates an ability to effectively communicate in the resume format. Clear, concise content. Resume is interesting.		

Has the program satisfied this outcome? **(Y/N)**	Comments: **The cadets appear to satisfy the outcome based on the rubric scores. However, many cadets, particularly those with publications, were unable to site themselves correctly. Many cadets were not able to independently demonstrate that they recognized skills they learned in the courses, and repeating back items listed during brainstorming sessions in class.** Final Grade: **4.1/5**	Assignment used for assessment: **CH365 Writing Assignment – Resume Draft 1**

(b)

Your Name: **Professor Biaglow**	Cadet Assessed: **Program-level (all cadets in CH365)**
Your Position: **Instructor, CH365**	Major of Cadet Assessed: **Chemical Engineering**

	1 – Needs Improvement	**1**	**2**	**3 – Meets Expectations**	**3**	**4**	**5 – Exceeds Expectations**	**5**	**N/A**
Engagement	No evidence of pre-professional activities.			References pre-professional activities are lacking or connections to chemical engineering are weak or implied.			Uses examples of pre-professional chemical engineering activities.	**4.6 ±.5**	
Recognition	Skills learned in chemical engineering courses taken in previous semesters are not listed.			Skills are listed, but the skills are vaguely described, or connection to chemical engineering concepts is not clear.			Identifies specific skills learned in chemical engineering courses.	**4.8 ±.4**	
Intellectual Growth	Unable to identify new concepts learned this semester.			Changes are apparent in document, but connections to recent activities in chemical engineering are weak or implied.		**4.3 ±1.1**	Addition of multiple skills acquired this semester.		
Communication	Resume lacks organization or cohesion. Numerous grammatical errors that may interfere with meaning. Target audience unclear.			Occasional grammar errors that do not impede meaning. Demonstrates ability to write a basic resume, but document is uninteresting and flat.		**4.3 ±.7**	Demonstrates an ability to effectively communicate in the resume format. Clear, concise content. Resume is interesting.		

Has the program satisfied this outcome? **(Y/N)**	Comments: **The purpose of the second draft was for cadets to update their personal skills inventory with new skills and attributes acquired this semester. The performance on the second draft was significantly better, and cadets seemed to take suggestions for improvement seriously. Some cadets still struggled with identifying new skills but got there with faculty feedback.** Final Grade: **4.5/5**	Assignment used for assessment: **CH365 Writing Assignment – Resume Draft 2**

Figure 4-23. Lifelong learning skills rubric with average data from cadet assessments from the resume writing assignment (drafts 1 and 2). Part (a) shows the results from draft 1 and part (b) for draft 2 of the writing assignment in CH365.

(a)

Your Name:	**LTC April Miller**	Cadet Assessed:	**CH485 Cadets**
Your Position:	**CH485 CD**	Major of Cadet Assessed:	**Chemical Engineering**

	1 – Needs Improvement	**1**	**2**	**3 – Meets Expectations**	**3**	**4**	**5 – Exceeds Expectations**	**5**	**N/A**
Contemporary	Does not address the assignment. Lacks contemporary context. Uses generic arguments or essay lacks specificity.			Discusses contemporary nature of issue but context is weak or implied. Examples are few or lacking.	**3.5 ±1.0**		Uses numerous examples and scholarly articles to illustrate contemporary nature of issue.		
Technical Competence	Demonstrates poor or incomplete understanding of transport phenomena.			Demonstrates some knowledge of the technical content, but explanation lacks depth.	**3.1 ±1.2**		Demonstrates exceptional knowledge of technical content.		
Synthesis of Ideas	Does not connect contemporary issue with concepts in chemical engineering.			Makes connections with chemical engineering concepts, but the connections are weak or implied.	**3.3 ±1.1**		Makes very clear connections between the issue and chemical engineering concepts.		
Communication	Writing lacks organization or cohesion. Numerous grammatical errors that may interfere with meaning. Thesis lacking or implied.			Occasional grammar errors that do not impede meaning. Demonstrates ability to write a basic essay, but lacks cohesion or completeness. Thesis not fully supported.	**3.0 ±1.2**		Demonstrates an ability to effectively communicate in the essay format. Fully supported, clear, concise thesis. Writing style was exceptionally clear and articulate.		

Has the program satisfied this outcome? **(Y/N)**	Comments: **Cadets were able to identify contemporary issue. They required work in discussing the technical aspect of the contemporary issue. Additionally, Cadets tend to just discuss points without a connection or overall premise. Most lacked an overall premise. As of draft 1, the program has not satisfied this outcome.** Final Grade: **3.2/5**	Assignment used for assessment: **Heat and Mass Transfer Writing Assignment - Draft 1**

(b)

Your Name:	**LTC April Miller**	Cadet Assessed:	**CH485 Cadets**
Your Position:	**CH485 CD**	Major of Cadet Assessed:	**Chemical Engineering**

	1 – Needs Improvement	**1**	**2**	**3 – Meets Expectations**	**3**	**4**	**5 – Exceeds Expectations**	**5**	**N/A**
Contemporary	Does not address the assignment. Lacks contemporary context. Uses generic arguments or essay lacks specificity.			Discusses contemporary nature of issue but context is weak or implied. Examples are few or lacking.		**4.5 ±.4**	Uses numerous examples and scholarly articles to illustrate contemporary nature of issue.		
Technical Competence	Demonstrates poor or incomplete understanding of transport phenomena.			Demonstrates some knowledge of the technical content, but explanation lacks depth.		**4.0 ±.6**	Demonstrates exceptional knowledge of technical content.		
Synthesis of Ideas	Does not connect contemporary issue with concepts in chemical engineering.			Makes connections with chemical engineering concepts, but the connections are weak or implied.		**3.9 ±.6**	Makes very clear connections between the issue and chemical engineering concepts.		
Communication	Writing lacks organization or cohesion. Numerous grammatical errors that may interfere with meaning. Thesis lacking or implied.			Occasional grammar errors that do not impede meaning. Demonstrates ability to write a basic essay, but lacks cohesion or completeness. Thesis not fully supported.		**3.9 ±.5**	Demonstrates an ability to effectively communicate in the essay format. Fully supported, clear, concise thesis. Writing style was exceptionally clear and articulate.		

Has the program satisfied this outcome? **(Y/N)**	Comments: **Cadets improved significantly, the majority clearly stated a premise. All Cadets were able to identify contemporary issue and improved on the technical aspect. Cadets still can work on connecting the details and technical aspect to the premise. The program now satisfies this outcome.** Final Grade: **4.1/5**	Assignment used for assessment: **Heat and Mass Transfer Writing Assignment - Draft 2 / Final Draft**
Your Name: **LTC April Miller**	Cadet Assessed: **6 x CH485 Cadets**	

(c)

Your Name: **LTC April Miller**				Cadet Assessed: **CH485 Cadets**					
Your Position: **CH485 CD**				Major of Cadet Assessed: **Chemical Engineering**					
	1 – Needs Improvement	**1**	**2**	**3 – Meets Expectations**	**3**	**4**	**5 – Exceeds Expectations**	**5**	**N/A**
Contemporary	Does not address the assignment. Lacks contemporary context. Uses generic arguments or essay lacks specificity.			Discusses contemporary nature of issue but context is weak or implied. Examples are few or lacking.			Uses numerous examples and scholarly articles to illustrate contemporary nature of issue.	**5.0 ±0**	
Technical Competence	Demonstrates poor or incomplete understanding of transport phenomena.			Demonstrates some knowledge of the technical content, but explanation lacks depth.			Demonstrates exceptional knowledge of technical content.	**4.7 ±.2**	
Synthesis of Ideas	Does not connect contemporary issue with concepts in chemical engineering.			Makes connections with chemical engineering concepts, but the connections are weak or implied.			Makes very clear connections between the issue and chemical engineering concepts.	**4.7 ±.3**	
Communication	Writing lacks organization or cohesion. Numerous grammatical errors that may interfere with meaning. Thesis lacking or implied.			Occasional grammar errors that do not impede meaning. Demonstrates ability to write a basic essay, but lacks cohesion or completeness. Thesis not fully supported.			Demonstrates an ability to effectively communicate in the essay format. Fully supported, clear, concise thesis. Writing style was exceptionally clear and articulate.	**4.8 ±.4**	
Has the program satisfied this outcome? **(Y/N)**	Comments: **Cadets that opted to submit the final draft were at the upper end of the rubric for Draft 2. The improvement was synthesis of ideas and adding more details with the technical aspect. This outcome is satisfied.** Final Grade: **4.8/5**						Assignment used for assessment: **Heat and Mass Transfer Writing Assignment - Final Draft**		

Figure 4-24. Contemporary issues rubric with average data from cadet assessments from the writing assignment in CH485. Part (a) shows the results after draft 1, part (b) after draft 2 and part (c) after draft 3.

6. Contemporary Issues Rubric. The rubric is described on page 4-12. Data are shown in **Figure 4-24** for the writing assignment in CH485. **Figure 4-24** (a) shows the results after the first draft of the assignment, (b) for the second draft, and (c) for an optional third draft. The results are summarized as averages in the rubric, with cadet average scores shown for each rubric item. The expected levels of attainment are color-coded red (indicating a need for improvement), yellow (minimal level of performance), and green (expectations are exceeded). All averages are in the green after the second iteration.

THIS PAGE INTENTIONALLY LEFT BLANK

Level of Achievement of Student Outcome 8:

On completion of the chemical engineering program, our graduates demonstrate an ability to Understand the chemical engineering curriculum, including:

- (8.1) Chemistry.
- (8.2) Material and energy balances
- (8.3) Safety and environmental factors.
- (8.4) Thermodynamics of physical and chemical equilibria.
- (8.5) Heat, mass, and momentum transfer.
- (8.6) Chemical reaction engineering.
- (8.7) Continuous and staged separation operations.
- (8.8) Process dynamics and control.
- (8.9) Modern experimental and computing techniques.
- (8.10) Process design.

Assessment Instruments and Frequency:

1. Fundamentals of Engineering Examination, once/yr.
2. Average Course Grades for Chemical Engineering Students, once/yr.

Assessment Results:

1. Fundamentals of Engineering Examination (FEE).

Table 4-3. FEE results for the Class of 2019, broken down by topic, and with comparison to the national averages.

Subject	**Outcome**	**Questions**	**USMA ChE**	**National** (expected level of attainment)
Chemistry	8.1	8	10.5	10.2
Material & Energy Balances	8.2	8	9.4	9.5
Safety, Health, & Environmental	8.3	5	10.5	9.8
Thermodynamics	8.4	8	9.4	9.3
Heat Transfer	8.5	8	10.2	9.8
Fluid Mechanics/Dynamics	8.5	8	9.5	9.8
Chemical Reaction Engineering	8.6	8	10.3	9.7
Mass Transfer & Separations	8.7	8	9.2	9.7
Process Control	8.8	5	10.0	9.8
Computational Tools	8.9	4	9.4	10.3
Process Design & Economics	8.10	8	10.6	9.7

2. Course grades.

Table 4-4. Course grades for AY2019 for comparison with the last six years.

Course ↓		Chemical Engineering Student Outcome 8								
		Chemistry	Mater. & Energy Bal.	Thermodynamics	Transport	Reaction Engineering	Separations	Dynamics & Control	Experiment & Compute	Process Design
		8.1	**8.2**	**8.4**	**8.5**	**8.6**	**8.7**	**8.8**	**8.9**	**8.10**
CH383	Organic Chemistry I	3.14								
CH365	Chem. Eng. Thermo.			3.68						
CH362	Mass & Energy Balances		3.63							
CH363	Separation Processes						3.76			
CH364	Chem. Reaction Eng.					3.27				
CH459	Chem. Eng. Laboratory								3.52	
CH485	Heat and Mass Transfer				3.14					
CH400	Chemical Engineering Sem.			4.08		4.08	4.08	4.08		
CH402	Chem. Eng. Process Des.									3.27
MA366	Vector Calculus									
ME311	Thermal-Fluid Systems I			3.67	3.67					
ME312	Thermal-Fluid Systems II			3.35	3.35					
CE300	Fund. Eng. Mech. & Des.									
EE301	Intro. To Elec. Engineering									
XE472	Dyn. Modeling & Control							2.94		
Average Grade 2019		3.14	3.63	3.69	3.39	3.67	3.92	3.51	3.52	3.27
Average Grade 2018		2.87	3.72	3.51	3.20	3.66	3.67	3.53	3.42	3.37
Average Grade 2017		3.15	3.21	3.65	3.25	3.66	3.67	3.31	3.54	2.73
Average Grade 2016		3.19	3.57	3.43	3.32	3.64	3.57	3.55	3.70	3.43
Average Grade 2015		3.33	3.63	3.43	3.33	3.72	3.71	3.60	3.67	3.40
Average Grade 2014		3.41	3.64	3.72	3.67	3.59	3.81	3.82	3.87	3.60
Previous 5-year Running Average *(expected level of attainment)*		*3.19*	*3.55*	*3.55*	*3.35*	*3.65*	*3.69*	*3.56*	*3.64*	*3.31*
Standard Deviation 2019		0.96	0.60	0.72	0.63	0.49	0.37	0.69	0.44	1.14

Table 4-5. Faculty evaluation of chemical engineering student outcomes after review of the data on pages 4-15 to 4-33.

Chemical Engineering Student Outcomes	**Faculty Evaluation**
On completion of the chemical engineering program, our graduates are able to:	
1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	4.94 ± 0.11
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	4.63 ± 0.12
3. Communicate effectively with a range of audiences.	4.00 ± 0.04
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	4.81 ± 0.19
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	4.50 ± 0.18
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	4.75 ± 0.08
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	4.75 ± 0.08
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	4.75 ± 0.23
5- Excellent; 4 – Very Good; 3 – Acceptable; 2 – Weak ; 1 – Poor	

Table 4-6. Advisory board evaluation of chemical engineering student outcomes (AY18).

Chemical Engineering Student Outcomes	**Advisory Board's Evaluation**
On completion of the chemical engineering program, our graduates are able to:	
1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	4.89 ± 0.15
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	4.67 ± 0.09
3. Communicate effectively with a range of audiences.	4.78 ± 0.19
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	4.89 ± 0.18
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	4.78 ± 0.11
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	4.44 ± 0.21
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	4.78 ± 0.68
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	4.78 ± 0.18
5- Excellent; 4 – Very Good; 3 – Acceptable; 2 – Weak ; 1 – Poor	

Table 4-7. Program director's summary of student outcomes performance (AY18).

Chemical Engineering Student Outcomes	**Program Director's Summary**
On completion of the chemical engineering program, our graduates are able to:	
1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	5
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	5
3. Communicate effectively with a range of audiences.	4
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	5
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	5
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	5
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	5
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	5
5- Excellent; 4 – Very Good; 3 – Acceptable; 2 – Weak ; 1 – Poor	

B. Continuous Improvement.

Over the past ten years, there have been several areas where program processes have led to efforts at program improvement. Some of these efforts were based on evaluation of performance on student outcomes, and some have been based on other information. Some efforts have been successful and some have had mixed results. They include:

- Introduction of experimental design in CH459 in AY15.
- Introduction of review lessons in mathematics and probability & statistics in CH400 starting in AY15.
- Introduction of daily economics quizzes in CH402 in AY16.
- Introduction of new course in chemical thermodynamics in AY16.
- Introduction of a new course in process control in AY19.
- Adjustment of credit hours of engineering topics.
- Older changes from the previous review cycle.

Introduction of experimental design in CH459 (senior lab course). This change was implemented AY2015 in an effort to bring our program into closer compliance with student outcome 6. This outcome requires that students demonstrate an ability to develop and conduct appropriate experimentation…" While the new outcome (ABET 6) has only been assessed by our program starting this year (AY2019), the previous version of this outcome (ABET b) required "ability to design and conduct experiments," is very close, and so the assessment process for this outcome has not changed. While assessment data was not pointing to this outcome as needing improvement, experiments were being conducted in a prescribed manner, with students following detailed procedures developed by the instructors. There were some advantages to this approach, chief among them being development of the ability to pay close attention to detail and the ability to read and follow instructions for complicated experiments. Nevertheless, the outcome calls for experiment development, and the course was re-aligned for that skill.

Figure 4-25 is a summary of the program averages for embedded indicators for student outcomes 1-7 taken from Figure 4-**8**, **Figure 4-10**, Figure 4-**12**, Figure 4-**14**, Figure 4-**16**, Figure 4-**19**, and Figure 4-**21** and similar data sets over the past six years. Each of the seven groups of bars corresponds to student outcomes 1-7. Each bar within each group corresponds to an academic year. Thus, data are shown for each outcome for six academic years from 2014 to 2019. Indicators for student outcome 6 are circled. The height of the bar represents the average scores on course activities, while the error bars represent minimum scores. The circled data set is the average of embedded indicators for student outcome 6. While this is a composite score taken from several courses, activities in CH459 contribute approximately 20% of the total score, with the balance coming from other courses that also cover this outcome.

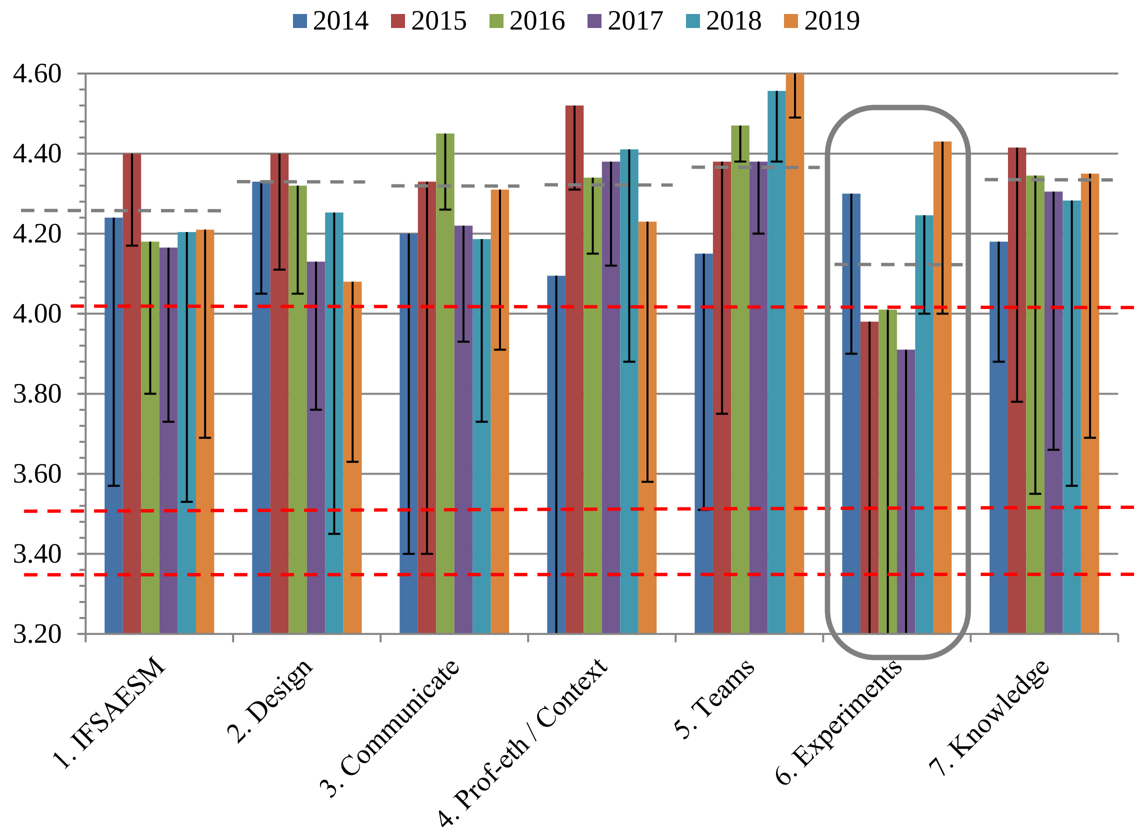


Figure 4-25. Summary of performance on embedded indicators for student outcomes 1-7. Data for student outcome 6, developing and conducting appropriate experiments, from 2014 to 2019, are circled.

The first important feature to consider in the outcome 6 data in **Figure 4-25** is the decrease in scores from 4.30 in AY2014 to 3.98 in AY2015, which is a drop of about 10%. This is due almost entirely to drops in scores in CH459. Based on the patterns observed for the other six outcomes, this change appears to be significant, and is coincident with the introduction of experiment design in CH459 (senior lab). The data stand out because the scores in outcome 6 were also the only group in all seven outcomes that dropped below 4. Then, in AY2018 and 2019, we see an increase in performance to about 4.45, surpassing the scores in AY2014. Before this increase, we observed a slight decline in AY2015, 2016, and 2017.

After AY2015, several changes were made at the course level to attempt to bring the scores back up. Perhaps the most significant change was the addition of faculty members to the course in AY2018, so that each student group in the course is paired with one instructor during the execution of the lab, providing an additional instructor contact that was not possible with fewer faculty. Other changes include the addition of safety stand-down and safety audits during the first lesson of each project. These exercises require the students to take careful inventory of the pilot plant and surrounding lab space, as well as tracing of fluid flow paths, electrical power, and signals through the pilot plants. "Routing and Inspection Checklists (RICLs)" were introduced in AY2016, which require students to develop detailed inspection and measurement protocols for use during the experiments. Finally, instructors now use a daily "IPR" process (in-progress review), where students are required to provide a daily briefing to the instructor, and the instructor reports back to the students the current grade on the scoring rubrics. Taken collectively, these actions seem to be having a positive impact on the scores, with corresponding increase in performance in AY2018 and AY2019.

Introduction of mathematics and probability & statistics review in CH400 (Professional Practice). Student outcome 8 for our program requires that our students demonstrate that they understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics, heat, mass and momentum transfer, chemical reaction engineering, continuous and stages separation processes, process dynamics and control, modern experimental and computing tools, and process design. These topics map directly to the specifications of the FE exam. By articulating the exam content as an additional student outcome, we have connected the FE exam to our program's student outcome assessment process. In addition to these topics, the FE exam also contains a significant number of questions covering basic mathematics and probability and statistics.

A very useful feature of the FE exam is that the National Council of Examiners for Engineering and Surveying (NCEES) provides a performance report to the students' home institutions. The report shows the average program performance, as well as national averages in each of the content areas of the exam. The report does not indicate how individual students performed. This report allows assessment of the collective program performance in each of the content areas.

Figure 4-26 shows selected data from the NCEES institutional reports for West Point chemical engineering from 2007 to 2019. NCEES reports results on a 0 to 15 scale, with 15 being equivalent to 100%. The data in **Figure 4-26** are plotted as differences between the West Point program scores and the national averages in each topic. Thus, the vertical line at 0 represents zero difference in scores, and the horizontal bars represent the program scores. Additionally, the national average standard deviations range from 2.1 to 3.6 for these five topics, so the values shown in the plots are generally within one standard deviation. Since NCEES does not provide standard deviations for the program scores, we do not base evaluation of year-to-year changes with confidence intervals or t-tests. Our process uses trends in the mean values, similar to what one would use in commercial stock analysis.

In **Figure 4-26** (a), the average mathematics scores show a clear downward trend from 2007 and 2013. In 2015, our program introduced review lessons in mathematics and in probability and statistics in CH400 Chemical Engineering Professional Practice. The introduction of these reviews was a result of a combination of these scores and survey results from the cadets, with surveys taken immediately after the exam, in which cadets consistently requested more mathematics review. The reviews initially took the form of self-study assignments in AY2015 and 2016, and later grew to include review lessons conducted by mathematics faculty. The result appears to be a positive "bounce" in the scores, with the program average changing from -2.25 to 0.80 between AY2014 and 2015.

The data appear to show an increase in performance in mathematics in AY2015 in response to program improvements. However, we are somewhat cautious in this interpretation because of other variables that may have influenced the scores. For example, NCEES introduced electronic testing for the first time in AY2015 and eliminated the pencil-and-paper exam format. In that same year, NCEES changed the comparator group reported back to the institution from all takers to first-time takers at ABET accredited institutions. These changes resulted in a drop in the national overall exam pass rate from 89.0% to 77.4% for chemical engineers, and it is unclear if they had an impact on the subject scores. Another reason for caution is that our efforts do not appear to have had a systemic impact on the scores in probability and statistics, **Figure 4-26** (b), with no clear trend emerging in that data despite the curricular changes in CH400.

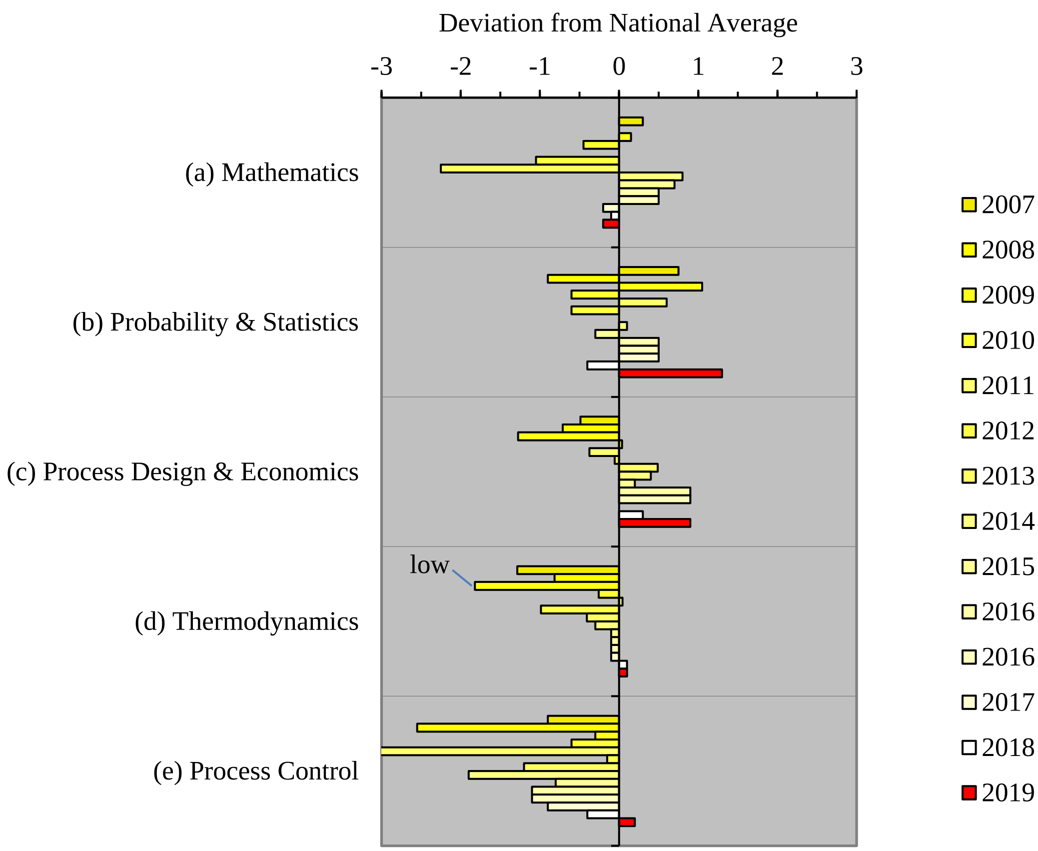


Figure 4-26. Deviation in FEE scores from national averages in (a) mathematics, (b) probability and statistics, (c) process design and economics, (d) thermodynamics, and (e) process control. The national average standard deviations range from 2.1 to 3.6 for these five topics.

Introduction of daily economics quizzes in CH402 (Process Design). **Figure 4-26** (c) shows average scores in the FEE for process design and economics from 2007 to 2019. The average scores are below the national average from 2007 to 2012 and above the average from 2013 to 2019. In 2013, the program introduced a FEE-style design exam into

CH402. This is a 55-minute exam with 13 multiple-choice questions covering design and economics. The exam not only tests content taught in the CH402 course, it serves as an additional practice exam for prepping for the FEE, in addition to the 3 exams given in CH400. Furthermore, the timing of the exam in the semester is right before spring break, which is also very close to when most cadets take the FEE. We believe this has had a positive impact on the FEE scores in this topic. The change in the exam to computer-based testing in 2015 probably did not impact these scores since that change occurred in 2015, and the change in scores was observed earlier. Then, to solidify the performance, in AY2016 we introduced a series of daily quizzes in CH402 that are designed to increase student preparation in engineering economics and therefore to help scores on the FEE. These are 10-minute multiple-choice quizzes patterned after questions that might be on the FEE, that also cover material in CH402. Quiz topics include equipment costing, cost indices, cost factors, components of capital cost, fixed versus variable costs, interest, cash flows, taxes, capitalized cost, profitability, and depreciation. Scores on the FEE exam appear to have increased in 2016 as a result but have since fallen slightly.

Introduction of new course in chemical thermodynamics. **Figure 4-26** (d) shows average scores in the FEE for thermodynamics from 2007 to 2019. The average values are below the national average from 2007 to 2018. The curriculum committee memo creating the course is dated 1 October 2012, contemporaneously documenting the rationale for creating the course based on assessment data. We realize the analysis and assessment that led to the creation of this course occurred more than 6 years ago, but the first iteration of the course was in AY2016, and assessment of responses in performance data as a result of this change is more recent and ongoing. For example, in AY2016, 2017, and 2018, we observed improved scores on the FEE. One could argue that the scores were already trending up from the low of -1.82 observed in 2009, but we did not know that when the course was proposed, and the curriculum memo cites data only up to AY2011, so we believe that the assessment and the resulting creation of the course were correct. This opinion is further strengthened by consideration of the averages. From 2007 to 2015, the cumulative average is -0.66 ± 0.62, while during the years CH365 has been offered, the average is -0.03 ± 0.12. The decrease in variability of the scores, indicated by the decrease in standard deviation, is itself a strong indicator that performance has improved in a meaningful way in this topic.

CH365 replaced physical chemistry (CH481) in our curriculum. Previously, our program covered the solution and reaction thermodynamics in CH481, with physical thermodynamics covered in MC311 and MC312 out of the mechanical engineering program. We still require the MC courses but have removed physical chemistry. CH481 is divided into about one-half thermodynamics and one-half chemical reaction kinetics. Before creating the new course, we previously attempted to supplement the chemical thermodynamics coverage in our program by adding thermodynamics lessons to the separations course. We did see some initial improvement after 2009 that may have been due to these changes. However, the performance improvement in this topic did not sustain itself. After discussions with the faculty, advisory board, and students, we decided to replace the physical chemistry course with a semester-long course on chemical engineering thermodynamics, allowing us to focus instruction on topics related to chemical process engineering thermodynamics for an entire semester as opposed to the half semester provided in physical chemistry. This means we obtained about 20 additional lessons at the expense of the chemical kinetics material. We realize that the trade-off will be less exposure to chemical kinetics, but this has not had any adverse effects in either chemical reaction engineering or in chemistry on the FEE.

A second reason for making this change had to do with our study of credit hours in chemical engineering curricula in various programs around the country. This study is detailed in Criterion 5, and included all chemical engineering programs in the U.S. From that study, we concluded that virtually all students in chemical engineering have a full course in chemical engineering thermodynamics that goes beyond the mechanical thermodynamics such as that covered in our mechanical engineering courses. We found that we were about one course short on this topic, which explains our relatively poor performance in this topic. Our working theory is that having a semester-long course in this topic brings us more into line with what is happening with chemical engineering education, and that scores should continue trending upward in this topic.

Introduction of a new course in process control. **Figure 4-26** (e) shows average scores in the FEE for process control from 2007 to 2019. The strong trend shown in this data is the consistently below-national-average performance of West Point chemical engineers in this topic. While somewhat close to the national average, we were concerned that our students performed below the national average in this topic since the program's inception. In the 17 years the current course has been part of the Chemical Engineering major, several attempts have been made at both the program and course levels to make changes intended to improve cadet performance in process control. These changes included creation of chemical engineering content for the current course, re-alignment of the process control thread in the chemical engineering curriculum, movement of the controls course from senior year to junior year, introduction of process control content in the follow-on senior lab course (CH459), and inclusion of review topics in the professional practice course.

Short of introducing a new course, attempts were made within the program to improve our students' performance in process control. For example, in 2006-2008, a chemical engineering professor worked closely with the course faculty to modernize the course and make it more relevant for the chemical engineers. They were constrained, however, to maintain the overall lesson plan and sequence provided for the general course since it is part of multiple engineering programs and shared between those departments. The result was that a number of lessons were allotted for chemical engineering-specific topics. Additionally, in 2010, lessons within the program's 1.5 credit hour CH400 Chemical Engineering Professional Practice course were designated specifically for reviewing process controls topics. Additionally, in 2014, approximately 15% of the senior lab course (CH459) was allocated for discussion and reinforcement of controls topics. This time is allocated to applied process control and understanding the controllers, indicators, and data acquisition within the overarching goal of designing and executing pilot plant operations experiments in the course.

Improvement in performance in process control has been particularly challenging. To leverage existing courses and conserve faculty time, our program utilized a course taught in another department to convey the necessary background in controls theory and practice. That course was thus responsible for desired topics for several disciplines requiring or desiring control theory, not just chemical engineers, including mechanical, electrical, and aeronautical engineers. Making changes to the course for the specific needs of chemical engineers, therefore, could not detract from the material provided to other disciplines. Moving forward, our efforts ultimately culminated in the creation of a new course, giving us flexibility to create more targeted course content. Specific program rationale based primarily on program assessment is more fully described and documented contemporaneously in our curriculum committee memo from 18 November 2016, clearly showing that program assessment featured prominently in the creation of the course.

Adjustments to Teaching Strategies in CH400. During AY2018 and AY2019, CH400 Chemical Engineering Professional Practice followed a more-or-less standard program of instruction. Cadets meet for class approximately 20 times during the semester. For each chemical engineering FEE topic, there is normally one problem set and one quiz taken in class. Upon completion of the in-class quiz, the remainder of class time is spent reviewing the quizzes and discussing problem-solving approaches. With respect to the FEE itself, cadets are allowed unlimited tries to pass with following caveat: no more than one try per 3-month period. The NCEES uses the quarter system whereby the year is broken into four equal 3-month quarters: January-March, April-June, July-September, and October-December. To guarantee that each cadet would have two opportunities to pass before graduation on 25 May, we get the first round of testing completed before 1 April. In the two weeks following Spring Break (and before 1 April) all 24 of the Class of '19 cadets took the FEE for the first time. Out of those 24, 21 passed on the first try. The cadets who did not pass were able to schedule an exam in the next FEE cycle (7 May). During the interim we conducted additional instruction, practiced on old FEE problems, and took an additional practice WPR. The three cadets who did not pass on the first try were also deficient in the course and understood that without passing the FEE they would not pass CH400. This provided additional motivation and all 3 cadets passed on the second try. A similar strategy was employed in AY2018, although only 1 of 3 cadets who failed on the first try passed on the second.

An additional strategy was employed in AY2019. Extra credit is earned in this course by cadets who do extra practice problems. Problems are computer graded and the results submitted to the instructor. Cadets can in principle do as many extra problems as they want. Previously, extra credit was awarded as it was earned. This year, extra credit was only awarded at the end of the academic term. This way, when cadets' grades are posted through their military chain of command, deficiencies appear in the grade reports, and the cadets' tactical officers can take additional motivational measures to encourage study, such as restriction of travel privileges on "B weekends." In this way, cadets are encouraged to re-double their efforts on the initial graded event and not rely on the extra credit. A negative consequence of this approach is that the cadets don't like it, and as a result, survey scores are somewhat lower in CH400 as a result. This can be seen in **Figure 4-9,** where the survey results can be seen to be somewhat lower in CH400 for student outcome 1. Cadets universally tell us that they appreciate the extra push once they pass the exam.

Pass rates on the FEE exam, shown in **Figure 4-27**, appear to be impacted by this approach. As can be seen in the figure, we achieved a 100% pass rate in AY2019 (including four cadets who passed on the second try). The averages in red are before and after the introduction of CH400 into the curriculum in AY2010, which was an assessment-based change from the previous review cycle. For comparison, national average pass rates are shown in Table 4- **8**.

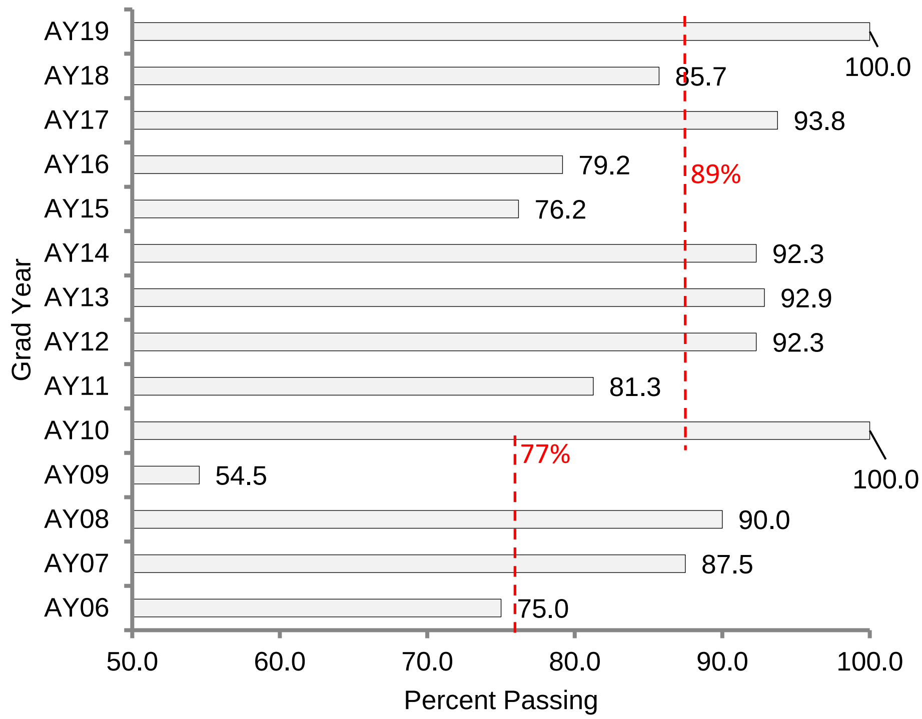


Figure 4-27. Pass rates for cadets in the USMA chemical engineering program from AY2006 to AY2019. The averages in red are before and after the introduction of CH400 into the curriculum in AY2010.

Table 4- 8. Comparison of national and USMA chemical engineering pass rates on the Fundamentals of Engineering Exam from 2006 to 2019.

Year	National Passing Percentage	USMA Passing Percentage	Year	National Passing Percentage	USMA Passing Percentage
2019	77.0	100.0	2012	85.1	92.3
2018	75.0	85.7	2011	87.0	81.3
2017	74.0	93.8	2010	87.0	100.0
2016	79.0	79.2	2009	84.0	54.5
2015	77.4	76.2	2008	87.0	90.0
2014	89.0	92.3	2007	87.0	87.5
2013	86.3	92.9	2006	87.0	75.0

Adjustment of credit hours of engineering topics. Engineering topics (ET) credit hours are shown by year in **Figure 4-27**. The red circles represent the program and the open circles are the ABET requirement, which changed from 48.0 to 45.0 credit hours in 2019. Previous increases in the program after accreditation were designed to ensure that the program was safely (~4.5 credit hours) above the minimum ABET requirement. This was because ET credit hours were assigned to courses normally associated with math and basic science, and we created a margin to ensure that the program credit hours can sustain any reduction resulting from an ABET audit. This situation is no longer the case. There are no longer any courses counted toward our ET total that are offered by math or basic sciences programs. Furthermore, the institution's ABET Committee instituted a formal procedure for vetting ET credit hours, further guaranteeing an accurate accounting. As an example, this committee recently reviewed and approved an increase in ET for IT105 from 0.5 to 2.0, bringing our program total to 52.5. This change resulted in turn from changes in the ABET definition of ET that allow inclusion of information technology toward that count.

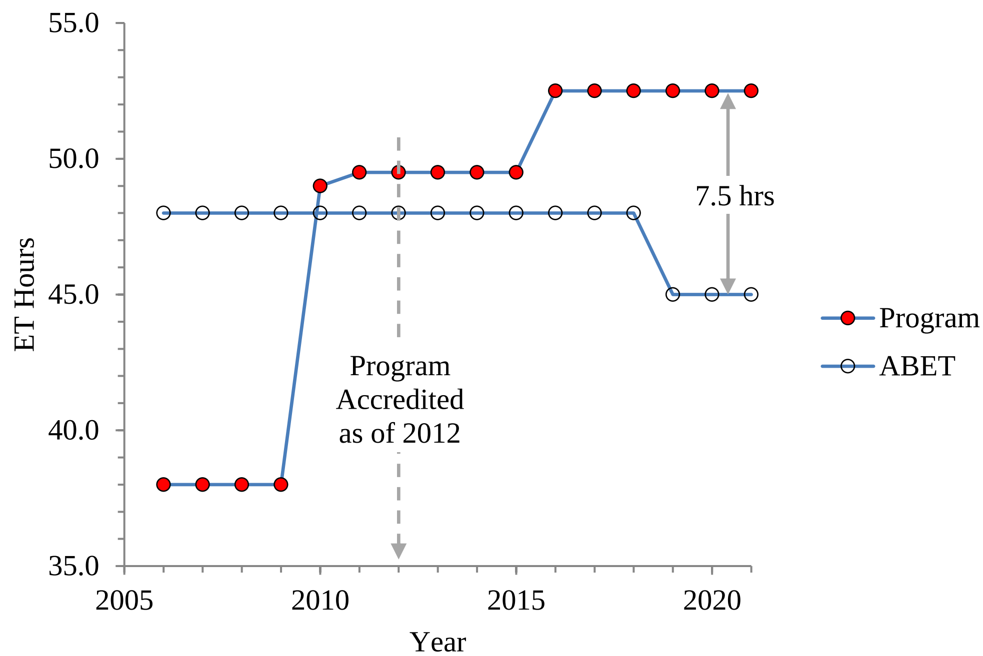


Figure 4-28. Credit hours of engineering topics in the chemical engineering program from 2006 to 2021.

As a result of the various changes, we are 7.5 credit hours above the ABET minimum. Moving forward, this will allow our program to introduce changes in the curriculum to take advantage of the margin. Such changes might be a reduction in the number of required courses, a reduction in credit hours in the currently offered courses, and possibly the introduction of a math/science elective into the program. This last option could be a choice between additional advanced chemistry, mathematics, physics, or biology, and would occur as a substitution for one of the engineering electives. The program will be considering these options over the next few years.

Older changes from the previous review cycle. The chemical engineering program has been involved in program improvement efforts for many years, and we are not new to this. Changes also occurred during the previous review cycle. These changes were discussed thoroughly in the previous ABET self-study report from 2014. Older changes from the previous review cycle include:

- Introduction of the professional practice course (CH400) leading to increased participation rate and performance in the FE exam.
- Introduction of a course in heat and mass transfer (CH485) leading to improved performance in fluid dynamics.
- Addition of engineering electives leading to increased credit hours of engineering topics.
- Adjustments to the reaction engineering, senior lab, and control courses.
- Addition of process safety content in the senior lab course.
- Adjustments to thermodynamics content in our physical chemistry and separations courses.
- Adjustment of the curriculum to more closely follow benchmark credit hour averages.
- Increase in credit hours in five of the chemical engineering courses, leading to a comprehensive lab program for computer aided design and use of CHEMCAD.

Summary. This section of the self-study report (Criterion 4) is rather lengthy, so in closing this section of the report, we felt it appropriate to provide some summary remarks here at the end of the section. Perhaps the most important take-away message is that we feel our program has demonstrated that it is engaged in a robust and systematic improvement process. We have collected and assessed many different types of data, including embedded indicators, student, faculty, and advisory board surveys, as well as nationally-normed exams, only a sample of which is shown in this report. The program has actively sought the opinions of its constituencies for program assessment as well as a number of other program improvement efforts. We have also demonstrated that we have been able to make a number of changes and adaptations in response to this input, and we have been able to implement these changes at a sustainable pace over the lifetime of the program. Finally, we believe we have demonstrated that some of these changes have had clear and measurable benefits for the students.

C. Additional Information

Copies of the assessment instruments and materials referenced in 4.A and 4.B will be available for review at the time of the visit. Other information showing evidence that the assessment results were evaluated and where recommendations for action were made will also be included.

THIS PAGE INTENTIONALLY LEFT BLANK

CRITERION 5. CURRICULUM

A. Program Curriculum

1. [Pages 5-2 to 5-4] Complete Table 5-1 that describes the plan of study for students in this program including information on course offerings in the required curriculum in the form of a recommended schedule by year and term along with maximum section enrollments for all courses in the program over the last two terms the course was offered. If there is more than one curricular path, Table 5-1 should be provided for each path. State whether you are on quarters or semesters and complete a separate table for each option in the program.
2. [Pages 5-5 to 5-6] Describe how the curriculum aligns with the program educational objectives.
3. [Page 5-7] Describe how the curriculum and its associated prerequisite structure support the attainment of the student outcomes.
4. [Page 5-8] Attach a flowchart or worksheet that illustrates the prerequisite structure of the program's required courses.
5. [Pages 5-9 to 5-11] Describe how your program meets the requirements in terms of hours and depth of study for each subject area (Math & Basic Sciences, Engineering Topics, and General Education) specifically addressed by either the general criteria or the program criteria.
6. [Pages 5-11 to 5-19] Describe the broad education component and how it complements the technical content of the curriculum and how it is consistent with the program educational objectives.
7. [Page 5-19 to 5-20] Describe the major design experience that prepares students for engineering practice. Describe how this experience is based upon the knowledge and skills acquired in earlier coursework and incorporates appropriate engineering standards and multiple design constraints.
8. [Page 5-20] If the program allows cooperative education to satisfy curricular requirements specifically addressed by either the general or program criteria, describe the academic component of this experience and how it is evaluated by the faculty.
9. [Page 5-20] Describe the materials (course syllabi, textbooks, sample student work, etc.), that will be available for review during the visit to demonstrate achievement related to this criterion. (See the 2019-2020 APPM Section I.E.5.b.(2) regarding display materials.) [Section Reference Changed – READ!]

B. Course Syllabi

In Appendix A, include a syllabus for each course used to satisfy the mathematics, science, and discipline-specific requirements required by Criterion 5 or any applicable program criteria.

[Red font page numbers were added by USMA Chemical Engineering. These page numbers are also hotlinks.]

A. Program Curriculum

Table 5-1. Chemical engineering curriculum, class of 2020.

Course (Department, Number, Title) List all courses in the program by term starting with the first term of the first year and ending with the last term of the final year.	Indicate Whether Course is Required, Elective or a Selected Elective by R, E or SE.[1]	*Subject Area (Credit Hours)*			Last Two Terms the Course was Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms Course was Offered[2,3]
		Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	Other		
Term 1 (Semester 1):						
MA103 Math Modeling/Intro Calculus	R	4.5			20-1, 20-2	19
CH101/151 General Chemistry I or Advanced General Chemistry 1	R	4.0			20-1, 20-2	20
EN101 Composition	R			3.0	20-1, 20-2	18
HI105/155 History of the United States or Advanced History of the United States	R			3.0	20-1, 20-2	18
IT105 Introduction to Computing and Information Technology	R		2.0	1.0	20-1, 20-2	18
MS100 Introduction to Warfighting	R			1.5	20-1, 20-2	38
PE116 Boxing	R			0.5	20-1, 20-2	30
Term 2 (Semester 2):						
MA104 Calculus I	R	4.5			20-1, 20-2	18
CH102 General Chemistry II	R	4.0			20-1, 20-2	18
EN102 Literature	R			3.0	20-1, 20-2	18
HI1108/158 Regional Studies in World History or Advanced Regional Studies in World History	R			3.0	20-1, 20-2	18
PE117 Military Movement	R			0.5	20-1, 20-2	42
PL100/150 General Psychology for Leaders or Advanced General Psychology	R			3.0	20-1, 20-2	18
Term 3 (Semester 3):						
MA205/255 Calculus II or Advanced Multivariable Calculus	R	4.0			20-2, 20-3	18
PH205/255 Physics I or Advanced Physics I	R	4.0			20-1, 20-2	19
Lx203 Foreign Language I	R			4.0	20-1,21-1	18
SS201/251 Economics or Advanced Economics	R			3.0	20-1, 20-2	18

(Continued on following page)

PY201 Philosophy & Ethical Reasoning or Advanced Philosophy and Ethics	R			3.0	20-1, 20-2	18
MS200 Fundamentals of Small Unit Operations	R			1.5	20-1, 20-2	19
PE215 Fundamentals / Personal Fitness	R			1.5	20-2, 20-3	24
Term 4 (Semester 4):						
MA364/365 Engineering Mathematics or Advanced Math for Scientists and Engineers	R	3.0			20-1, 20-2	18
CH362 Mass & Energy Balances	R		3.5(√)		19-2, 20-2	19
PH206/256 Physics II or Advanced Physics II	R	4.0			20-1, 20-2	21
Lx204 Foreign Language II	R			4.0	20-1, 20-2	18
SS202/252 American Politics or Advanced American Politics	R			3.0	20-1, 20-2	18
EV203 Physical Geography	R	2.5		0.5	20-1, 20-2	18
PE2xx Lifetime Physical Activity	R			0.5	20-1, 20-2	35
Term 5 (Semester 5):						
CH363 Separation Processes	R		3.5(√)		19-1, 20-1	19
EE301 Fundamentals of Electrical Eng.	R		3.5		20-1, 20-2	18
CH383 Organic Chemistry I	R	3.5			19-1, 20-1	21
MC311 Thermal-Fluid Systems I	R		3.5(√)		20-1, 20-2	18
MA206 Probability & Statistics	R	3.0			20-1, 20-2	18
PL300 Military Leadership	R			3.0	20-1, 20-2	19
PE32x Survival Swimming	R			0.5	20-1, 20-2	8
Term 6 (Semester 6):						
CH364 Chemical Reaction Engineering	R		3.5(√)		19-2, 20-2	18
CH367 Automatic Process Control	R		3.0(√)		19-2, 20-2	18
MC312 Thermal-Fluid Systems II	R		3.0		20-1, 20-2	18
MC300 Fundamentals of Engr. Mech. & Des.	R		3.0		20-1, 20-2	18
SS307/357 International Relations or Advanced International Relations	R			3.0	20-2, 20-3	18
MS300 Platoon Operations				1.5	20-1, 20-2	18
PE360 Combat Applications	R			0.5	20-1, 20-2	30
Term 7 (Semester 7):						
CH459 Chemical Engineering Laboratory	R		3.5(√)		19-1, 20-1	12
CH485 Heat & Mass Transfer	R		3.5		19-1, 20-1	15
CH365 Chemical Engineering Thermodynamics	R		3.0		19-1, 20-1	19

(Continued on following page)

Engineering[4] Elective 1	SE		3.0		20-1, 20-2	18
Engineering[4] Elective 2	SE		3.0		20-1, 20-2	18
PE450 Army Fitness Development	R			1.5	20-1, 20-2	21
Term 8 (Semester 8):						
CH402 Chemical Engineering Process Design	R		3.5(√)		19-2, 20-2	18
CH400 Chemical Engineering Professional Practice	R		1.5		19-2, 20-2	18
Engineering[4] Elective 3	SE		3.0		20-1, 20-2	18
HI302 History of the Military Art	R			3.0	20-2, 20-3	18
LW403 Constitutional Military Law	R			3.0	20-4, 20-5	18
MX400 Officership	R			3.0	20-1, 20-2	37
TOTALS (in terms of semester credit hours)		41.0	52.5	58.5		
Total must satisfy minimum credit hours	Minimum Semester Credit Hours	30.0	45.0			

Table 5- 1

1. **Required** courses are required of all students in the program, **elective** courses (often referred to as open or free electives) are optional for students, and **selected elective** courses are those for which students must take one or more courses from a specified group.
2. For courses that include multiple elements (lecture, laboratory, recitation, etc.), indicate the maximum enrollment in each element. For selected elective courses, indicate the maximum enrollment for each option.
3. Values were taken from the USMA Redbook at the time of writing of this document.
4. Engineering electives must contain a minimum of 3 credits of engineering topics.

Instructional materials and student work verifying compliance with ABET criteria for the categories indicated above will be required during the campus visit.

Alignment of Curriculum with Program Educational Objectives.

The content and structure of our curriculum aligns with the program educational objectives. The content of the program is articulated in student outcome 8. Student outcome 8 is essentially our interpretation of the Program Criterion. As explained in Criteria 3 and 4, student outcome 8 was derived from comparison with content areas of the Fundamentals of Engineering Exam and by benchmarking against other chemical engineering programs. Different types of curriculum alignment are shown in Tables 5-2 to 5-5. Table 5-2 shows a comparison of student outcome 8 with the program educational objectives. The bullets (●) designate where the program believes there is alignment between a curricular area and an objective.

Table 5-2. Mapping of chemical engineering curriculum (student outcome 8) to Program Educational Objectives.

(● designates alignment)		Chemical Engineering Program Educational Objectives			
		… leadership & chem. engineering expertise	… infrastructure and operational problems	… graduate school & advanced study progs.	… clear and precise tech. communication
↓ Our graduates demonstrate an ability to understand the chemical engineering curriculum, including:		1	2	3	4
8.1	Chemistry	●	●	●	
8.2	Material & Energy Balances	●	●	●	●
8.3	Safety, Health, & Environmental Factors	●	●	●	●
8.4	Thermodynamics	●	●	●	
8.5	Heat, Mass, and Momentum Transfer	●	●	●	●
8.6	Chemical Reaction Engineering	●	●	●	●
8.7	Continuous & Staged Separation Ops.	●	●	●	●
8.8	Process Dynamics & Control	●	●	●	
8.9	Modern Exp. & Comp. Techniques	●	●	●	●
8.10	Process Design	●	●	●	●

Another view of alignment with objectives is through the assessment process. As explained in Criterion 4, program assessment is accomplished primarily through the 8 student outcomes and is aligned with them. The student outcomes align, in turn, align with the program educational objectives. Alignment of student outcomes with program educational objectives is shown in Table 5-3 (also shown earlier as Table 3-2 in Criterion 3). The bullets (●) designate where the program believes there is alignment between an outcome and an objective. Alignment of curriculum and outcomes is discussed in the next section. Tables 5-3 and 5-4 provide a more specific mapping of curriculum to student outcomes.

Table 5-3. Mapping of Student Outcomes to Program Educational Objectives.

(● designates alignment)		Chemical Engineering Program Educational Objectives			
		… leadership & chem. engineering expertise	… infrastructure and operational problems	… graduate school & advanced study progs.	… clear and precise tech. communication
↓ Chemical Engineering Student Outcomes		1	2	3	4
1	Identify, formulate, and solve….	●	●	●	
2	Apply engineering design …	●	●		
3	Communicate effectively …	●			●
4	Recognize ethical responsibilities …	●			
5	Function on effectively on a team …	●			
6	Develop and conduct experiments ...	●	●	●	
7	Acquire and apply new knowledge ...	●	●	●	
8	Understand the curriculum ….	●	●	●	

Description of How the Curriculum and its Associated Prerequisite Structure Support the Attainment of the Student Outcomes.

The curriculum supports the attainment of student outcomes in two ways. First, we use various assignments in the courses to measure the attainment of the outcomes. Table 5-4 illustrates this assessment structure. Courses designated with a "3" have unique embedded indicators with a clear rubric or cut scale. There are other activities in the courses that are also assessed by the course directors but contribute less directly to the attainment of outcomes, designated with a "2." That is, the activities are graded but the relationship to the outcomes is either convoluted or part of the outcome is not assessed.

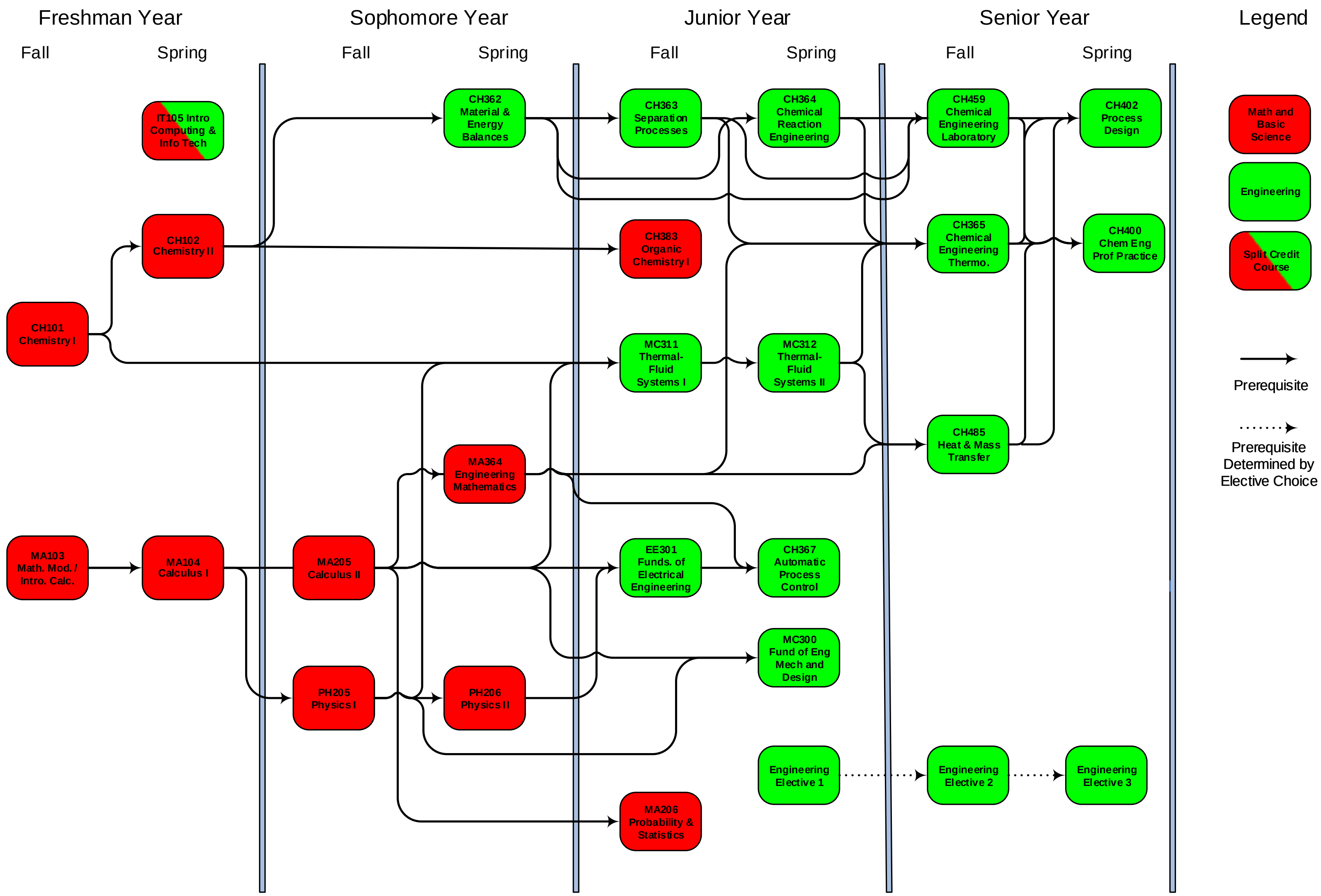
The associated prerequisite structure of the program's required courses is shown in Figure 5-1. Further details of curricular support of the student outcomes is found in detailed description in Criterion 4.

Table 5-4. Alignment of Chemical Engineering Curriculum with Student Outcomes 1-8**.**

		ChE Student Outcomes 1-8 (1-7 Identical to ABET Criterion 3 1-7)							
ChE Course ↓	3 = strong relationship 2 = strong to medium relationship 1 = weak relationship blank = very weak or no relationship	IFSAESM	Design	Communication	Prof eth / Context	Teams	Experiments	Knowledge	Curriculum
		1	2	3	4	5	6	7	8
CH362	Mass & Energy Balances	3		2	2			2	3
CH363	Separation Processes	3	2	3			1		3
CH364	Chemical Reaction Engineering	3	2	3		3	1	3	3
CH365	Chemical Engineering Thermodynamics	3	2	3				2	3
CH367	Intro. to Automatic Process Control	3		3		3			3
CH459	Chemical Engineering Laboratory	3	2	3		3	3		3
CH485	Heat & Mass Transfer	3	1	2	2		3	1	3
CH400	Chem. Eng. Professional Practice	3			3			3	3
CH402	Chemical Engineering Process Design	3	3	3	3	1	1	3	3
MC311	Thermal-Fluid Systems I	3				3	3		2
MC312	Thermal-Fluid Systems II	3		3			3	3	2
CH383	Organic Chemistry I	2		1		1	2	1	3
EE301[1]	Fundamentals of Electrical Engineering	2	2	2	1	2	2	1	2
MA364[1]	Engineering Mathematics	2							2
MC300[1]	Fundamentals of Engr. Mech. & Des.	2	2	1	1	2	1	1	2

[1] Courses not used by chemical engineering for program-level assessment.

Flowchart illustrating the prerequisite structure of the program's required courses.



Program Compliance with the Hours and Depth of Study Requirements.

Criterion 5 calls for 30 credit hours of math and basic science and 45 credit hours of engineering topics. As shown in Table 5-1, the USMA chemical engineering program contains 41.0 credit hours of math and basic science and 52.5 credit hours of engineering topics. These totals are based on analysis of published credit hours in the USMA Redbook (course catalog). Each course in the Redbook has its credit hours partitioned as basic science (BS), engineering topics (ET), or mathematics (MA). For example, the "Credit Hours" Redbook entry for CH402 Chemical Engineering Process Design is "3.5 (BS=0.0, ET=3.5, MA=0.0)." The chemical engineering program is 7.5 ET credit hours above the ABET-required ET minimum and 11.0 credit hours above the ABET-required MA/BS minimum of 30.0.

Some courses in the Redbook have credit hours that are split between ET, MA, and BS. An example is IT105 Introduction to Computing and Information Technology, which is a required course for all cadets at West Point, and therefore contributes to the credit hour totals for chemical engineering. The Redbook entry for IT105 is "3.0 (BS=0.0, ET=2.0, MA=0.0)."

IT105 is maintained and managed outside of our department, and the credit hours and engineering content are controlled by the departments that manage the courses. Since the course contributes to our program credit hour content, changes in the course content of IT105 and other split-credit courses need to be periodically monitored to ensure the fidelity of the course content with the assigned ET credit hours. To address this issue, USMA has created a review and certification process, run by the USMA ABET Committee, that reviews courses where there is a request by any of the programs that use the course. The review subcommittee includes approximately 10-12 ABET program evaluators and commissioners currently on the USMA faculty. The committee was carefully calibrated against a sample set of questions which showed that the committee has a consistency of about 90% in terms of its ability to distinguish between course content in math, basic science, and engineering. This committee carefully reviews courses on request of the host departments or client programs. IT105 was last reviewed in the Fall of 2018 and the committee found that the credit hour listing is an accurate reflection of the course content. The results of this survey and the calibration data can be made available to the visit team upon request (or see paper 6 at https://www.hofstra.edu/academics/colleges/seas/seas-fall16-asee-conference-papers.html).

The program criteria require that "the curriculum must provide a thorough grounding in the basic sciences including chemistry, physics, and/or biology, with some content at an advanced level, as appropriate to the objectives of the program. The curriculum must include the engineering application of these basic sciences to the design, analysis, and control of chemical, physical, and/or biological processes, including the hazards associated with these processes." The topics covered in the USMA chemical engineering program include advanced chemistry, material and energy balances, safety and environmental factors, transport phenomena, reaction engineering, separation operations, process dynamics and control, experimental and computing techniques, and process design. Student outcome 8 is derived from these topics and published in the USMA Redbook. Table 5-5 is a mapping of the 15 required chemical engineering courses in the curriculum to the topics in student outcome 8. Addition information on program compliance is provided in this report the Program Criterion.

Table 5-5. Alignment of Curriculum with Student Outcome 8.

ChE Course (Program Required) ↓	3 = strong relationship 2 = strong to medium relationship 1 = weak relationship blank = very weak or no relationship	Student Outcome 8 Topics									
		Chemistry	Material & Energy Balances	Safety, Health, and Environ. Factors	Thermodynamics	Heat, Mass, & Momentum Transfer	Chemical Reaction Engineering	Continuous & Stages Separation Ops.	Process Dynamics & Control	Modern Exp. & Comp. Techniques	Process Design
		8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	8.10
CH362	Mass & Energy Balances	1	**3**		2		2	2		**3**	2
CH363	Separation Processes	2	2		2	2		**3**		**3**	2
CH364	Chemical Reaction Engineering	2	2		2	2	**3**			**3**	2
CH365	Chem. Eng. Thermodynamics	2	2		**3**		1	1		**3**	2
CH367	Intro. to Automatic Process Control		2			1	1		**3**	**3**	2
CH459	Chemical Engineering Laboratory	2	2	**3**	2	2	2	2	2	**3**	2
CH485	Heat & Mass Transfer		2			**3**	2	2		3	
CH400	Chem. Eng. Professional Practice	**3**			**3**	**3**	**3**	**3**	**3**	**3**	
CH402	Chemical Eng. Process Design	2	2	**3**	2	2	2	2	2	**3**	**3**
MC311	Thermal-Fluid Systems I	1	2		**3**	**3**				2	
MC312	Thermal-Fluid Systems II	1	2		**3**	**3**				2	
CH383	Organic Chemistry I	**3**		2			2	2		2	
MA364	Engineering Mathematics				1	1			2	2	
EE301	Fundamentals of Electrical Eng.								2	2	
MC300	Fund. of Engr. Mech. & Des.									1	

As in Table 5-4, Table 5-5 uses a “blank to 3 scale” that indicates the degree to which the course supports the outcome. As before, if there are graded events or other assessments in a course that are specifically linked to the assessment of that outcome, the outcome-to-course correlation is indicated with a 3. As discussed above, there are other activities or attributes of the courses that may be important even if they are not directly assessed, in which case the correlation is indicated with a 2. For example, in CH362, the concept of enthalpy is used extensively in the development of enthalpy balances, so the correlation to thermodynamics is assigned a 2 instead of a 3. The course is primarily designed to teach application of conservation equations with and does not teach the nature of thermodynamic properties or how to calculate them. Therefore, thermodynamics is a secondary topic, even though specific skills and knowledge normally associated with thermodynamic are used in the course. Also, as mentioned earlier, the reason for assigning "2" versus "3" depends upon the course and the strength of the course director's assessment. In each case, there is a strong relationship between at least one course in the chemical engineering curriculum to each of the student outcome 8 topics.

The broad education component and how it complements the technical content of the curriculum and how it is consistent with the program educational objectives.

The chemical engineering program is structured to provide both breadth and depth components that establish a firm background in chemical engineering and that also establishes a foundation for further study in the discipline. Depth of study is achieved in the required technical courses in the program's curriculum. Breadth of study is achieved in two ways, with respect to other engineering disciplines and with respect to humanities and social sciences.

The breadth in engineering component includes courses in mathematics, chemistry and physics. Furthermore, the program provides cadets with exposure to at least three engineering fields outside of chemical engineering – electrical, civil, and mechanical engineering. This breadth of coverage experience is an optimal environment for teaching students to function on multidisciplinary design teams, which is critical in both military and industrial settings. Furthermore, the professional component of the chemical engineering program is complemented by the extensive USMA core curriculum that provides students with a broad education in the humanities in such areas as economics, law, leadership, and foreign languages, all necessary to function in a global societal context.

The depth component is represented by a well-structured hierarchy of courses, beginning with a solid foundation in mathematics and basic science. In follow-on engineering courses (courses containing ET) students learn to create analytical and empirical models of chemical systems and perform introductory-level design of chemical processes. Ultimately in the upper division engineering courses, cadets design chemical process equipment, and integrate these designs with other subsystems in a manner consistent with the standards of professional practice.

The curriculum is consistent with the Program Educational Objectives and Student Outcomes. The major elements of the program support achievement of student outcomes and provide a basis for future achievement of program educational objectives beyond graduation. The major elements include:

- *<u>A well-structured progression of design content integrated throughout the curriculum</u>*. The chemical engineering design experience is organized to meet the previously-discussed chemical engineering student outcomes and support program educational objectives. Through the use of small design projects in the engineering courses, students learn the concept of design. These projects are relatively narrow in scope and simple in character. They serve primarily to build students' confidence and to demonstrate practical applications of engineering concepts learned in the classroom. In subsequent courses the design projects become progressively broader in scope, more complex, more ambiguous, and subject to real-world constraints. Students must learn to work with incomplete or inadequate information and must solve problems that have no single correct answer. This progression develops mastery of a logical thought process, promotes creativity, provides experience working with ambiguity, and facilitates understanding of the broader context within which engineering solutions are developed.

- *A major, comprehensive design experience*. The chemical engineering program culminates in a major, comprehensive design experience. Details of the culminating design experience are described under "Describe the major design experience…" later in this section.

- *High quality laboratory experiences integrated throughout the curriculum*. In the basic science, engineering courses, students conduct experiments and analyze and interpret laboratory data as a means to understand the behavior of chemical systems and to enrich their understanding of the analytical models developed in the classroom. Many of the laboratories are not separate courses. In many cases, lab experiences are integrated into classroom courses to emphasize the connections between the classroom and the laboratory. In several courses, students are asked to develop an experiment to demonstrate the validity of a theoretical model developed in earlier classes. The senior chemical engineering laboratory course is a stand-alone laboratory course due to the complex nature of the pilot plant systems, with a few lectures to cover common principles such as error analysis or safety. Unit operations require a significant amount of hands-on experience and integration of theory from earlier courses. The stand-alone format gives students the depth of exposure they need with the equipment to facilitate experimentation in chemical process engineering. Laboratory exercises include a requirement for a written report to encourage student analysis and reflection and to enhance students' technical writing skills.

- *Use of computers and design codes as problem-solving tools*. Computers and associated computer-aided modeling and analysis software packages are important tools of the chemical engineering profession; thus, our students develop knowledge and confidence in their use as they advance through the program. The chemical engineering curriculum introduces appropriate computer software packages as early as possible in the curriculum and requires use of these programs in subsequent courses. Students learn spreadsheet and Mathematica computational software in their core science and mathematics courses. Chemical engineering courses continue the development of Mathematica and introduce CHEMCAD as a flow process simulator early in the curriculum. Mechanical engineering courses also introduce MATLAB and Engineering Equation Solver (EES). The program curriculum reinforces proficiency by including appropriate spreadsheet and computational software requirements in homework assignments, laboratory exercises, and design projects. Computer software enhances the realism and relevance of the students' educational experience and enables solution of larger, more complex problems. In particular, flow-process simulations of pilot plants with CHEMCAD during the senior lab course form a significant basis for more formal process design work during the following semester in senior design. Finally, dynamic simulation software is used in the Automatic Process Control course to teach controller tuning and in the Professional Practice course to teach plant operations.

- *Team-based projects and laboratories integrated throughout the professional component of the curriculum*. Engineers work in teams and students often learn more effectively in teams. The chemical engineering program uses team-based projects and/or laboratories in nearly every course. Teamwork and collaboration are actively encouraged during homework projects, particularly in the more advanced chemical engineering electives.
- *Emphasis on high-quality oral and written communication skills throughout the program*. To a large extent engineers communicate the results of their work through formal reports, plans and specifications, and well-organized and clearly presented analysis and design computations. The chemical engineering program develops written communication skills by requiring students to prepare clear, well-organized solutions to homework problems and by requiring formal technical reports for laboratories, design projects, and independent study projects. In all cases, instructors assess the quality of the written communication and the content of the product. Instructors normally penalize poorly communicated solutions with a grade reduction. Students must also actively participate in class and respond to instructor questions. Through interactive classroom participation, students develop confidence in speaking. In many courses, students have graded oral presentations associated with projects. Instructors grade oral communications skills in addition to the technical content of the presentation.
- *Emphasis on the standards of professional practice*. All graduates of the chemical engineering program will serve as commissioned officers in the United States Army. Therefore, a significant portion of the Academy curriculum beyond chemical engineering is geared toward officership within the Army. The standards of officership are compatible with professional practice within the chemical engineering profession. Thus, it is critical to the success of the program that chemical engineering graduates are intimately familiar with chemical engineering professional practice, as practiced in industrial settings, to the extent possible in an academic setting. 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 engineering practitioners, 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. Students must identify any applicable standards for their capstone design project and discuss these in their final report. Finally, all chemical engineering cadets take the Fundamentals of Engineering Examination during the spring semester of the senior year.
- *High quality Advanced Individual Academic Development opportunities to supplement the classroom experience*. Students have the opportunity to spend three to four weeks in the summer at one of a number of technical engineering laboratory facilities around the world, including industrial, government and DoD facilities.

Students participate as investigators in on-going technical projects, applying concepts learned in the chemical engineering program. On occasion students will continue the work during the academic year, either as an Individual Research project or as a capstone design project.

- *A faculty team that serves as a model of professional excellence for students*. The mission of the U.S. Military Academy is to develop leaders of character for the U.S. Army. Our graduates spend a substantial portion of their undergraduate experience in direct contact with members of the faculty. Thus, faculty members have an important responsibility to contribute to student leader development. The most important means by which faculty members contribute to leader development is to set an example of professional excellence in every interaction with students both in and out of the classroom. Chemical engineering faulty members, both military and civilian, embody the Army values of loyalty, duty, respect, selfless service, honor, integrity, and courage. They demonstrate the highest level of professional competence and personal conduct so that students are motivated to emulate them in their own professional careers.
- *A broad, substantive humanities core*. The USMA core curriculum is the principal means by which the Academy accomplishes its Leader Development and Academic Program Goals. The core curriculum enriches and enhances the chemical engineering program by enhancing cadets' understanding of contemporary issues and by providing the broad perspectives necessary to understand the impact of engineering solutions in a global and societal context.

In a broader sense, in the area of moral and ethical development, the USMA curriculum prepares students to assume their roles in the profession of arms. The entire professional staff and faculty at the U.S. Military Academy support the moral and ethical development of the students. The honor code by which the cadets live is an ideal embodied in the meaning of professionalism. "A cadet will not lie, cheat, or steal or tolerate those who do," are behavioral standards nurtured throughout a cadet's development. Formal training takes place as part of the Cadet Character Education Program (CCEP) program during the academic year and during summer military instruction. The Commandant oversees the Academy's CCEP program through the Simon Center for the Professional Military Ethic. The CCEP implements instruction separately and progressively to each of the four year-groups of students. Students interact with faculty volunteers who share their perspectives and experience in the Armed Forces, with industry, and at other civilian institutions. Typically, a CCEP team consists of members from the faculty and members from the Commandant's staff.

The Department of English and Philosophy teaches a core class, PY201 (Philosophy and Ethical Reasoning), a three-credit class taken by all cadets, usually in the sophomore year. This course provides an early academic base for further formal or informal ethics training and instruction. In addition to providing instruction and practical exercises in moral reasoning and some fundamental analysis of egoism, relativism, utility, and virtue ethics, PY201 devotes considerable attention to professional ethics. Although the professional ethics in this course is applied to the military profession, the principles employed are also applicable in a broad sense to engineering, and the course helps cadets develop their capacity for clear and critical thinking. Students must write a paper that addresses a contemporary moral problem by analyzing the ethical views studied. Students choose issues for the paper from currently publicized problems in medical, legal, social, computer, and engineering ethics.

Table 5-6. Mapping of Academic Program Goals to Program Educational Objectives.

(● designates alignment)	Chemical Engineering Program Educational Objectives			
	… leadership & chem. engineering expertise	… infrastructure and operational problems	… graduate school & advanced study progs.	… clear and precise tech. communication
↓ Academic Program Goal (APG)	1	2	3	4
1. Graduates communicate effectively with all audiences.				●
2. Graduates think critically and creatively.	●	●	●	
3. Graduates demonstrate the capability and desire to pursue progressive and continued intellectual development.			●	
4. Graduates recognize the ethical issues and apply ethical perspectives and concepts in decision-making.	●			
5. Graduates apply science, technology, engineering, and mathematics concepts and processes to solve complex problems.	●	●	●	
6. Graduates apply concepts from the humanities and social sciences to understand and analyze the human condition.		●		●
7. Graduates integrate and apply knowledge and methodological approaches gained through in-depth study of an academic discipline.	●	●	●	
Overarching Goal: Graduates integrate knowledge and skills from a variety of disciplines to anticipate and respond appropriately to opportunities and challenges in a changing world.	●	●	●	●

The complementary nature of the broad educational component and its association with chemical engineering program educational objectives is illustrated by the academy's

Academic Program Goals (APGs). The APGs are published in the document "Educating Army Leaders" (EAL) for faculty use in curricular design. The EAL is publicly available on the internet at https://westpoint.edu/ by clicking "Academics," then "Academic Leadership," and then "Academic Curriculum." The APGs are listed in Table 5-6, along with a cross-walk with the chemical engineering program's educational objectives. Since the APGs provide guidance for curricular design, they provide an overarching view of the academic program at West Point, which includes engineering and humanities and social sciences programs.

Each APG is accompanied by statements of what graduates can do, which are essentially academy-level student outcomes that are assessed by all programs at West Point, including core humanities and social sciences courses as well as engineering programs. Details of these assessments are contained in Academic Goal Team assessment reports summitted by these teams to the Dean's office once every calendar year. Many of the APGs are satisfied through the humanities and social sciences courses, such as the communication and ethics goals (APGs 1 and 2). In these two cases, direct assessment is accomplished through embedded indicators in the core courses such as in PY201 and MX400 (Officership) as well as other courses such as LW403 and SS307. Assessment of other APGs occurs through the summary reports submitted by the programs ("EXSUMs"), where programs such as chemical engineering document performance against student outcomes (such as ABET 1-7). Data in these EXSUM documents are also used by the Academic Goal Teams for assessment of the APGs.

Student Preparedness for a Professional Career and Further Study in the Discipline

The chemical engineering program is benchmarked against content areas within the Fundamentals of Engineering (FE) exam. This exam represents a synopsis of relevant engineering skills, and passage of the exam is required for licensure in all 50 states. Thus, the content of the exam is considered by practitioners to contain appropriate material for those seeking a license for professional practice in the engineering disciplines. The exam contains both general engineering and chemical engineering content determined by professional and academic practitioners. The exam specifications are published at https://ncees.org/engineering/fe/. Alignment of program outcomes with FE content is shown in Table 5-7. As shown in the table, the chemical engineering curriculum covers all content areas. Additional coverage is provided by the program engineering electives, but since these vary from student to student, they are not included in the table.

The chemical engineering program at USMA provides coverage in content areas that are also derived from comparison with programs at civilian institutions. This is done to ensure that our graduates can transition smoothly into graduate programs in these institutions or into civilian engineering jobs after leaving military service. Table 5-8 is a comparison of the USMA chemical engineering curriculum to the other chemical engineering programs accredited by ABET. The collection of schools in the 2012 data in Table 5-8 represents colleges and universities with graduate programs, as well as schools with primarily undergraduate programs. All 159 programs in the ABET database in 2012 were examined using curricula and course catalogs available on the internet.

The program USMA chemical engineering program compares favorably in most of the topical areas. According to Table 5-8 we are about 2.2 credit hours low in design, but this analysis does not account for design content in other courses besides CH402. If we add credit for design projects in CH362, CH363, CH364, MC311, and MC312, the USMA design total will be much closer to the national average. We are comfortable that our students are receiving adequate design experience in the program.

Table 5-7. Alignment of the USMA chemical engineering courses with the Fundamentals of Engineering chemical exam specifications.

	FE Exam Question Coverage (Chemical Exam) (from http://cbt.ncees.org. effective January 2014)															
↓ Program Course	Mathematics	Probability and Statistics	Engineering Sciences	Computational Tools	Materials Science	Chemistry	Fluid Mechanics & Dynamics	Thermodynamics	Material & Energy Balances	Heat Transfer	Mass Transfer and Separation	Chemical Reaction Engineering	Process Design & Economics	Process Control	Safety, Health, & Environment	Ethics & Professional Practice
CH362				●					●							
CH363				●							●					
CH364				●								●				
CH365				●				●								
CH367				●										●		
CH459				●											●	
CH485				●			●			●	●					
CH400																●
CH402				●									●		●	
MC311				●			●	●								
MC312				●			●	●								
CH383						●										
MA364	●			●												
EE301			●													
MC300			●		●											
CORE	●	●	●	●									●			●
% Test	8	4	4	4	4	8	8	8	8	8	8	8	8	5	5	2

Table 5-8. USMA Chemical Engineering Credit Hours versus National Averages.

Course Content	*USMA*[1]	*2012 Avg*[2]	*1994 Avg*[3]
Design	3.5	5.7	4.9
Laboratory	3.5	4.1	3.7
Reactor Design	3.5	3.1	1.9
Separations/Unit Operations	3.5	3.0	3.2
Control	3.0	3.0	2.3
Material & Energy Balances	3.5	3.6	3.6
Transport Phenomena	6.8[3]	6.3	11.7
Chemical Engineering Thermodynamics	3.0	4.8	4.2
Chemistry (General and Organic)	11.5	14.7	19.0
Physics	8.0	7.7	7.7
Mathematics (through ODEs)	16.5	14.8	14.5
Computer Programming and IT	3.0	2.4	3.6
Probability and Statistics	3.0	1.0	3.0
Electrical Engineering	3.5	1.0	3.8
Civil Engineering/Materials Science	3.0	0.9	3.8
Philosophy and Ethics	3.0		
Economics	3.5		
English Composition and Literature	6.0		
Physical Geography	3.0		
American Politics	3.0		
International Relations	3.0		
Psychology	3.0		
History and Regional Studies	6.0		
Constitutional Law	3.0		
Foreign Language	8.0		
Physical Education	5.5		
Military Science	7.5		

[1] Average of 159 schools in the Unites States found in the ABET database. See paper 30 at https://www.hofstra.edu/academics/colleges/seas/seas-fall16-asee-conference-papers.html.
[2] From R.N. Occhiogrosso and B. Rana, *J. Chem. Eng. Ed.*, 184-187 (Summer 1996).
[3] Transport is roughly 3.3 credit hours from MC311/312 and 3.5 credit hours from CH485.

Credit hours for USMA are also relatively low in chemistry. Students at USMA take 2 semesters of General Chemistry (8.0 versus 7.7, USMA vs. National) and this is fairly close, well within the standard deviation of 1.8 in the national average. The bulk of the difference is from Organic Chemistry, with USMA cadets taking one course while most programs require two. Once again, the standard deviation in the national average for organic chemistry is 2.1 so we are within about one standard deviation, and many programs are lower. This discrepancy has not resulted in any sort of shortcoming in our assessment of our performance in chemistry indicators. For example, our scores on the FE exam in advanced chemistry, which is essentially general and organic chemistry, are at or above the national average in almost every year our students have taken the exam. In fact, we saw no impact on this indicator when the second semester was removed from the program.

Our number of credit hours in physical chemistry dropped to zero in AY2016. As discussed in Criterion 4, the program decided to replace physical chemistry with chemical engineering thermodynamics in order to improve our scores in thermodynamics on the FE exam. Interestingly, in Table 5-8, there seems to be a strong trend downward in physical chemistry between 1994 and 2012. Many programs have eliminated physical chemistry as a requirement altogether to make room for other electives. Of the 159 schools surveyed, the mode (most common answer) for physical chemistry is 0.0, with 47/159 (or 30%) requiring no physical chemistry. Follow-on program assessment indicates that the chemical thermodynamics that was removed from the program by dropping the physical chemistry course was more than adequately compensated for with the addition of chemical thermodynamics content taught from the engineering perspective.

Adequacy of Time and Attention for Each Curricular Component

Determination of adequacy of time is addressed in two ways; first, with respect to credit hours compared to national averages in each curricular area, and second, with respect to performance on the FE Exam. The first measure, comparison with national credit hour averages, was discussed above and is summarized in Table 5-8.

The second measure by which we assess adequacy of time is with respect to performance on the FE exam. All students take the exam to emphasize the importance of professional registration in the continuous development of engineering skills. Over the last ten years (AY10 to AY19), 100% of our students opted to take the exam. During those years, our pass rate on the exam is 89%. Over the last 5 years, after the introduction of computer-based testing, our passing average is 87%, while the national average in chemical engineering dropped from 87% to 77%. So, over the last 5 years, we are +10% above the national average as a program. Generally, the strong performance of our students on this exam gives us a high degree of confidence that adequate time is being allotted in the various subject areas. Performance in the individual subject areas in Table 5-7 shows relative strengths and weaknesses in those subjects, and we use that information as input for program improvement, as discussed in Criterion 4 in this self-study.

Major design experience.

The chemical engineering program culminates in a major design experience in which cadets must apply and synthesize concepts from their previous courses. This capstone project typically involves designing a chemical process that addresses a real-world need. In recent years, we have used the student design problems from the AIChE as part of the National Student Design Competition. These problems are multidisciplinary, contemporary, comprehensive, and suitable for a 30-day intensive design experience. Further, the timing of the projects fits in very well with the USMA student schedule, allowing us to position the problem at the end of the senior year at a time when almost all other courses have wound down. More recently, we have used home-grown design problems such as the atmospheric crude unit in AY20. The advantage is that these projects allow us to go beyond the 30-day window allowed for the AIChE design problems, providing about 8 weeks or ½ of a semester for the projects.

The project includes a problem statement that requires the student to re-define the problem for themselves within the constraints given in the problem. The problem definition phase requires significant literature review of journals, encyclopedias, and patents. Students are specifically required to apply chemical principles, such as by creating chemical mechanisms, for their design project using skills learned in chemistry courses. They are further called on to apply engineering concepts learned in Chemical Reaction Engineering to determine the configuration, size, cost, and heat duty of chemical reactors, as well as to determine the amount of catalyst required. They apply the concepts from Separation Processes to design feasible separations, including type, cost, size and number of separators. They use concepts from Heat and Mass Transfer as well as Thermal-Fluids to determine the number, type, and cost of heat exchangers and pumps. This concept has been expanded in AY20 to study optimal energy integration in the final design. Students use concepts from Automatic Process Control and Chemical Engineering Lab to construct P&IDs, design safe control schemes, and to account for safety and environmental hazards.

As they progress through the problem, students identify social, technological, economic, and political considerations; they develop functional and aesthetic requirements, develop alternative concepts, and select a solution. They create a detailed design of the selected solution using a flow process simulator (CHEMCAD), test and redesign of the selected solution, and deliver the prototype design in the form of written report to the client (design professor). Students work in teams on capstone projects, which enables them to fine tune their teamwork skills. Students are seriously constrained by availability of time, which forces them to work efficiently and to carefully plan their activities. Additionally, to develop communication skills, students conduct oral desk-side briefings at intermediate points in the project. These discussions are informal but last from 30-90 minutes, allowing both assessment of and feedback on their technical approach. As a result of this experience, students discover how the various sub-disciplines of chemical engineering fit together in a single comprehensive design, gain practical experience working under real-world constraints, and further refine both oral and written communications skills.

Appropriate engineering standards and multiple constraints are utilized throughout the major design experience. Examples from the current year include requirements that students develop constraints for sulfur and water content in refined petroleum products and that they and incorporate them into their designs. Engineering design standards are incorporated into the design software and utilized by students during the design phase. Examples are numerous and include TEMA standards for heat exchanger design as well as commonly used guidelines for equipment design such as in mechanical design of distillation trays and safety codes for vessel thickness.

Use of cooperative education to satisfy curricular requirements.

The Chemical Engineering program does not offer cooperative education to satisfy curricular requirements.

Description of the materials that will be available for review.

During the visit, evaluators will be provided with samples of displayed course materials including course syllabi, textbooks, example assignments and exams, and examples of student work, typically ranging from excellent through poor. Course documentation will include three binders in electronic form, named ABET Binders I, II, and III. ABET Binder I is a compilation of course assessments and will contain documents for the previous 6 years including the record year. ABET Binders II and III only pertain to the record year (AY2020), and will contain the assignment solutions, and examples of outstanding, fair, and poor cadet work for each graded assignment. Binder II contains examinations. Binder III contains Design Problems, Computer Problems, Homework, and Lab Reports.

CRITERION 6. FACULTY

A. Faculty Qualifications

[Page 6-2] Describe the qualifications of the faculty and how they are adequate to cover all the curricular areas of the program and also meet any applicable program criteria. This description should include the composition, size, credentials, and experience of the faculty. Complete Table 6-1. Include faculty resumes in Appendix B.

B. Faculty Workload

[Page 6-7] Complete Table 6-2, Faculty Workload Summary, and describe this information in terms of workload expectations or requirements.

C. Faculty Size

[Page 6-7] Discuss the adequacy of the size of the faculty and describe the extent and quality of faculty involvement in interactions with students, student advising and counseling, university service activities, professional development, and interactions with industrial and professional practitioners including employers of students.

D. Professional Development

[Page 6-9] Provide detailed descriptions of professional development activities for each faculty member.

E. Authority and Responsibility of the Faculty

[Page 6-12] Describe the role played by faculty members with respect to course creation, modification, and evaluation, their role in the definition and revision of program educational objectives and student outcomes, and their role in the attainment of the student outcomes. Describe the roles of others on campus, e.g., dean or provost, with respect to these areas.

[Red font page numbers were added by USMA Chemical Engineering.]

A. Faculty Qualifications.

The composition, size, credentials, and experience of the faculty supporting the chemical engineering program are described in Table 6-1 and summarized in Table 6-3. Table 6-1 is a listing of faculty qualifications. Table 6-3 contains a summary of the faculty experience and activities derived from the CVs in Appendix B. These tables describe only those faculty from the department who teach in the chemical engineering program. Thirty four additional faculty support this program from other departments. Their CVs are included in Appendix B, but they are not listed in Tables 6-1 or 6-2. These table entries can be found in the self-studies for their home programs. Within the Department of Chemistry and Life Science, contributing faculty include chemists and engineers, including chemical, nuclear, and bioengineers. From the other departments, we are supported by mechanical, electrical, civil, and other engineers, as well as mathematicians from the Department of Mathematical Sciences for the Engineering Mathematics course. Also, two of the chemical engineers listed in Table 6-1 do not teach any of the required chemical engineering courses. COL Burpo teaches the Bioengineering elective and LTC Cowart has not arrived yet. They are listed because they are in the pool of available chemical engineers in the department, and they are available to teach chemical engineering courses should they be needed.

Composition.

The faculty of the Chemical Engineering Program is made up of members of the active duty Army and civilians. There are three categories of military, including Professors USMA, Academy Professors, and rotating faculty. Civilian faculty members include tenured or tenure-track faculty. Military and civilian faculty members hold conventional academic ranks of instructor (master's level military only), assistant, associate, and full professor. Each of these categories will be described below.

Professors, United States Military Academy (or Professors USMA). This academic title can be held by up to 29 military professors at the Academy. These officers are permanently assigned to the Academy to provide senior leadership. Once appointed, they may serve until mandatory retirement at age 64. Candidates for these positions must hold a Ph.D. and have an outstanding record of academic achievement. They must demonstrate both breadth and depth and have more than 15 years of military experience before reporting to the Academy. These faculty follow the traditional academic promotion process. The credentials and process for appointment to this position are described in detail in DPOM 3-19, "Procedures for Selecting Professors United States Military Academy."

Academy Professors. Academy Professors are active-duty Army officers typically at the rank of lieutenant colonel or colonel who are permanently assigned to the Academy. They provide leadership and program continuity, and are heavily involved in administration, mentoring of junior faculty, teaching, and research. They must either hold a Ph.D. or be capable of earning one as their first assignment, and typically begin their appointment at the academic rank of assistant professor, although they may be appointed at higher ranks depending on their academic credentials. Academy Professors should have approximately 15 years of military experience prior to appointment. This means the 15 years of experience may include the time it takes to earn the doctorate. The actual length of service in the program varies depending on the career trajectory of the individual, and there is no set length of time for this appointment. However, Academy Professors typically reside in the program for about 7-8 years after they arrive, and they typically depart at the age of mandatory retirement from the Army (typically 30 years of total service). The credentials and process for appointment to this position are described in detail in DPOM 3-20, "Procedures for Selecting Academy Professors." The Chemical Engineering Program currently has one Academy Professor (LTC James) who arrived in AY2017.

Rotating Military Faculty. Rotating military faculty are career Army officers who attend civilian universities to earn an advanced degree, followed by a 2- or 3-year tour at the Academy to teach and conduct research. After completion of their tour of duty at West Point, they return to the Army for other assignments. Their primary responsibilities are teaching and student mentorship. They may also actively participate in scholarship and a wide range of student activities. These officers provide practical military experience and play an especially important role in mentoring cadets.

The rotating military faculty members fall into two distinct groups, those who are on their first teaching tour and those who are on their second. The first-tour military faculty members have a master's degree, and they typically start their teaching tours as captains with about eight to ten years of prior active duty military service. They begin at the academic rank of instructor and may advance to assistant professor in their third year. Advancement is by nomination of the Department Head to the Dean for approval. Second-tour rotating military faculty members typically have a doctorate, hold a military rank of lieutenant colonel and an academic rank of assistant or associate professor. Since they are at USMA on a second tour of duty, they have anywhere from three to six years of total teaching and academic experience. Sometimes, these faculty members can extend for a third tour at West Point depending on their personal circumstances and the needs of their military branch.

Rotating military faculty candidates are directly recruited by the various departments at the Academy. Our department uses the Total Army Personnel Information Management System to screen for and identify suitable candidates, who are then encouraged to apply through the Academy's Web-Enabled Tracking and Selection System. Departments may also keep records on outstanding cadets and track their careers individually. Once identified, these faculty candidates are then encouraged to apply for positions at the Academy. All applications are reviewed by a department faculty committee and recommendations are made to the Department Head for final selection. This results in a mix of candidates with USMA and ROTC backgrounds, all of whom attend civilian institutions for their graduate schooling. The entire process is described in detail in DPOM 3-10, "USMA Military Rotating Faculty Selection." More details of this process can be found in Criterion 8 of this self-study.

Civilian Faculty. Civilian faculty members engage in teaching, scholarship, student and faculty mentorship and counseling, and service. They provide leadership, continuity, breadth and depth of experience, and subject matter expertise to their respective programs. Civilian faculty members at the Academy can hold any academic rank, as determined by their qualifications, and are permanently appointed upon achievement of the academic rank of associate professor. Some civilian faculty at the Academy (but not currently in the chemical engineering program) are non-tenure track and have term appointments for up to three years. Prior to this year, civilian faculty had either renewable or non-renewable contracts for up to ten years. For example, a civilian faculty member who reached the rank of associate professor received a 6-year renewable contract, and full professors received a 10-year renewable contract. As of this year, civilian faculty who achieve the academic rank of associate professor can now be permanently appointed in a system that more closely resembles a traditional tenure track. However, the renewable contract system that was in place prior to this year was very similar to tenure, since contracts were renewed indefinitely unless there was a serious, demonstrated breach in their professional responsibilities.

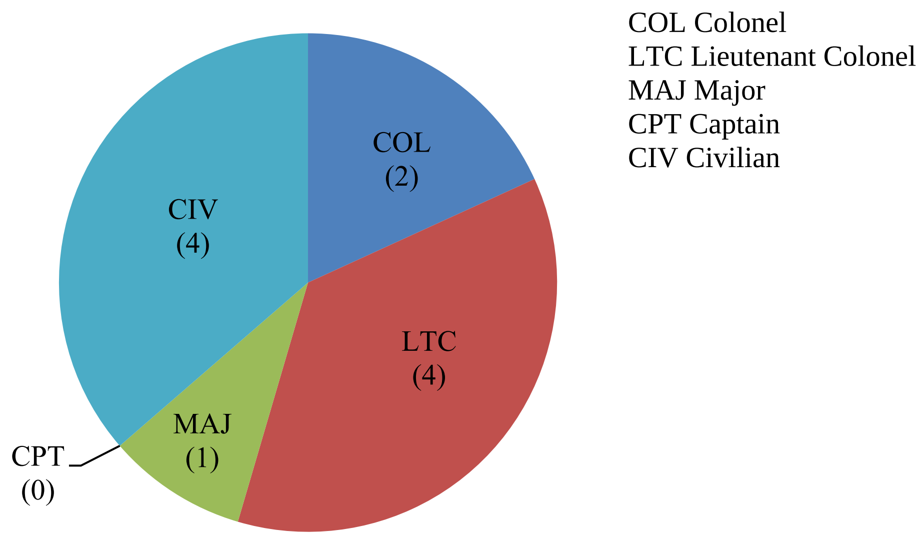


Figure 6- 1. Composition of department program faculty by rank. The total of 11 faculty members counted here includes 10 currently working in the department and one additional faculty member who is starting in the fall.

Figure 6-1 shows the current distribution of the department's program faculty by rank. The 11 department program faculty are either chemical engineers or other engineers (bio- or nuclear engineering) and the civilians are chemical engineers and chemists. As can be seen in the figure, 4 out of 11 are civilian. Among the military, there are 2 colonels, 4 lieutenant colonels, 1 major, and no captains currently (although junior rotating faculty at the rank of captain arrive yearly). The numbers shown in figure 6-1 are somewhat higher in terms of percentages than what is seen on average at the Academy. For example, the number of civilians academy-wide is about 25% and the percentage of faculty holding a Ph.D. in the program is higher than average. This is because department program electives are generally two sections and the CD is also the sole instructor. In large enrollment courses such as MC311 or MC300, there are multiple sections and some of these are taught by master's level faculty.

Faculty Size.

There are currently 44 total faculty members supporting the 15 required courses in the Chemical Engineering Program. This total includes program faculty in the department as well as those teaching courses outside of our department. This number is somewhat large for the size of the program because the courses outside of our department support several engineering programs. As a result, they have large enrollments with multiple sections requiring allocation of multiple faculty members. For example, MC300 has 18 sections with 18 cadets per section and is supported by 11 faculty members from the Department of Civil and Mechanical Engineering. Other courses with large numbers of sections include MC311 (12 sections with 7 faculty members), MC312 (7 sections with 4 faculty members), EE301 (7 sections with 7 faculty members) and MA364/5 (7 sections with 5 faculty members), for a total of 34 faculty teaching chemical engineering cadets in the large enrollment courses outside of the department. CVs for these faculty members are also included in Appendix B.

The total number of faculty members supporting the chemical engineering program has grown significantly, from 28 in 2008 to 38 in 2014 to 44 in 2020. This number has grown with the enrollment in the program over those years, as our cadets are populating an increasing number of sections in the large-enrollment courses. The Department of Chemistry and Life Science has also increased its complement of chemical engineers, from 4 in 2008 to 7 in 2014 to 10 in 2020. The growth in number of faculty is due to primarily to the increased size of the program, which has grown steadily from 3 cadets in the class of 2005 to 29 in the class of 2020, as well as the addition of new chemical engineering courses during those years. The numbers indicate that the institution has a track record of supporting increased program enrollment as well as the addition of courses with the addition of new faculty. Also, since program faculty in our department typically teach one elective per semester and we are currently teaching two sections per course, we can sustain moderate program growth into future years.

Credentials.

The faculty credentials are summarized in Tables 6-1 and 6-3, and faculty CVs are provided in Appendix B. The program currently has 9 out of 10 doctorate-level and 1 master's-level faculty members. This means that 90% of our faculty have a doctorate, which is somewhat higher than other engineering programs at West Point. Three of our department faculty members have taken and passed the Fundamentals of engineering exam. While we currently do not have any professional engineers in the department, cadets work with several PEs in the civil and mechanical engineering courses. Also, as can be seen in Appendix B, graduate degrees of our faculty members, both junior and senior, are from Tier-I graduate institutions.

After arrival at West Point, the academic credentials of the faculty are maintained through the academic promotion process as described in Dean's Policies and Operating Manual (DPOM) 5-3. In summary, to achieve academic promotion, all faculty members, including senior faculty as well as junior rotating faculty, must demonstrate proficiency in the five USMA faculty domains of teaching, scholarship, faculty development, cadet development, and service. Five of the ten of the department faculty are at the academic rank of associate or full professor, meaning that their credentials have been thoroughly reviewed and approved by the Credentials and Promotions Committee. The academic process is outlined in more detail below in the section on Faculty Development. All faculty, including those who have been academically promoted and those who have not, are mentored informally by senior military and civilian faculty members in the program.

Formal mentorship occurs through the annual military and civilian performance evaluation systems, described in more detail below.

The overall competence of the faculty of the Chemical Engineering program can be measured by the education, diversity of backgrounds, engineering experience, teaching experience, level of scholarship, and participation in professional societies. Table 6-2 (Faculty Analysis) and individual faculty member resumes in Appendix B provide information on each faculty member's experiences. Table 6-3 summarizes indicators of faculty competency, and it is clear, both from these indicators, and from student success on the FEE, as well as in graduate school and career progression, that the overall competency of the faculty is adequate to cover the mentorship needs and curricular areas of the program.

Experience.

The Academy makes heavy use of rotating military faculty. Over 50% of the academy faculty is composed of rotating faculty members. The remainder of the faculty is composed of about 25-30% senior military officers and 20-25% civilian faculty members. As a result, USMA has a larger proportion of its faculty without a doctoral degree than some institutions. This is by design and has several benefits regarding the Academy's mission. These faculty members are mid-grade Army officers, who are successful professional practitioners in the career fields that the students will enter upon graduation. This is extremely valuable for providing effective role models who can also provide career guidance to the cadets. Officers who are selected for faculty positions are highly qualified professionally and intellectually. They were handpicked from the Army and sent to the nation's leading universities to earn master's degrees prior to their assignment to the USMA.

USMA is committed to the rotating faculty system due to the benefits of having Army officers teach at USMA. They have recent Army experience and are familiar with the Army constituency. They are exposed to up-to-date developments in their academic discipline, having recently completed graduate school. They undergo an intensive teaching experience while here, which represents value added to their skills as they move on to other Army assignments. The rigorous teaching experience, both in the core courses and in the advanced electives, enhances the level of competency of these officers within their field of expertise. This is an advantage for these officers as they progress into more technical assignments in the Army. The primary drawback to the rotating faculty system is the relatively short amount of time that they are assigned to USMA. This is because USMA functions within the Army officer rotation system, which functions on the basis of three-year assignments. Because of the desire to maintain a strong rotating faculty contingent at West Point, they are provided with a high degree of mentorship and a rigorous development plan, described in detail below.

The experience level of the faculty is adequate to support the curriculum. Experience is listed in Table 6-1 and summarized in Table 6-3, and resumes are provided in Appendix B. The average amount of teaching experience is 9.9 years for the department faculty members in the program, with seven of ten having five or more years of teaching experience. The average number of years of teaching experience for those faculty members having five or more years of experience is 12.4 years. Six of the ten faculty members have ten or more years of experience as active duty Army officers, and two of the civilians have about two years each of industrial experience. Table 6-3 also shows that the average years of teaching experience has increased from 2014 to 2020 from 8.3 to 9.9 years, which is noteworthy because of the rotating nature of the faculty.

B. Faculty Workload.

Faculty workload is summarized in Tables 6-2 and 6-3. From Table 6-2, an average of about 60% of faculty time is spent on teaching, with the remainder split by about 17%/23% between research and other duties. From Table 6-3, the average number of courses taught per term is 1.2 in the department, not counting independent study courses. This means there is about a one- to two-course teaching load per semester. In the outside departments, the number is higher, since many faculty mentor design teams in the capstone courses, which have significantly higher enrollment than the chemical engineering design course. While the teaching load is somewhat high, it is not unreasonable when compared to other institutions. Based on informal conversations with colleagues at other institutions and observations during several recent ABET PEV visits, our teaching load is similar to what is found at research universities.

Given the amount of administrative duties, scholarship, service, mentoring, and counseling requirements, the overall workload appears to be reasonable. This is reflected in the amount of scholarship being produced. That is, given the teaching, counseling, mentorship, and committee duties, the faculty have been able to use the available time to establish productive research programs. This is accomplished using student researchers during the semesters. Also, many faculty members use the summer months for scholarship activities and collaborations with researchers at other institutions. As a result, the amount of scholarship appears to be healthy. As shown in Table 6-3, there have been 54 journal articles and 106 presentations and manuscripts in conference proceedings in the last five years, as counted from the CVs in Appendix B and by polling the faculty. Additionally, some faculty members have produced books and patents and participate in consulting activities. Since scholarship activities are critical for academic promotion, the rate of academic promotion reflects the faculty's ability to meet this requirement. While exact statistics are not available, informal observations and conversations with our Promotions and Credentials Committee indicate that most faculty members who are nominated for academic promotion are successful in ultimately obtaining the promotion. Since the amount of scholarship and the promotion rate appears to be healthy, the overall workload appears to be compatible with the institutional expectations for academic promotion as well as expectations for successfully teaching the courses in the program.

C. Faculty Size.

The overall faculty size (described in Section 6.A) is sufficient for student interactions, service, professional development, and interactions with practitioners. The ten faculty from the Department of Chemistry and Life Science are available for student advising and counseling in the program. It is important to point out that the USMA Chemical Engineering Program is multidisciplinary, with faculty drawn from and shared among several different departments. This helps to ensure that we will continually have enough faculty members associated with the program. This also ensures that we can maintain our typically small section sizes, which provides for optimal interactions inside and outside of the classroom.

Student-Faculty Interaction. Student-faculty interaction is strong. As most of the faculty is in the military, the profession the cadets will enter soon, there is great interest on the part of the faculty to develop the cadets through mentorship. This commitment to the cadets extends beyond the classroom. Many of our faculty (both military and civilian) serve as officer representatives or coaches for cadet teams and clubs. Many serve as mentors for the professional military ethics education program conducted during the academic year. Many more volunteer to sponsor freshman cadets and continue that sponsorship throughout their time at the Academy. Additionally, each summer 4-6 officers from our department work directly with cadets during their summer military training at the Academy, with similar numbers from each of the other departments.

Student Advising. As outlined in detail under Criterion 1 of this self-study, all faculty members are expected to take a personal interest in their students and provide advising and counseling services. In addition, many faculty members are involved to some extent in the three formal counseling programs: Departmental Academic Counselors (DACs), Company Academic Counselors (CACs), and Periodic Development Review (PDR) requirements. Most faculty members serve as DACs, responsible for advising students on their academic programs and approving the selections made. All students at USMA are assigned a DAC in the department of their major and stay with that DAC as far as possible until they graduate. Some faculty members volunteer to be a CAC for either the freshman or sophomore (until selection of major) class in a cadet company. The CAC advises cadets on the academic program and its opportunities, assists them in the major selection process, and counsels cadets deficient in courses during an academic term and cadets on academic probation.

Every faculty member is required to submit a Cadet Periodic Development Review (PDR) on five cadets during each semester. The PDR is primarily for the cadet and for their tactical officer, and it is automatically sent to them. The report is designed to rate a cadet's development according to Army standards of leadership. A faculty member is required to personally counsel the cadets on whom he/she writes a PDR, and many faculty use multiple meetings with the cadets in the PDR process to help the cadet develop professionally.

University Service Activities. Senior faculty members participate in the majority of university service activities, although junior faculty can also participate in some committees. This participation in the overall governance of the Academy is crucial to ensure the long-term goals of the Academy are achieved. It is typical for senior faculty to serve on two or more committees for the Academy. Examples include the Academic Board, the Admissions Committee, various Academy Goal Committees, ABET Committee, Credentials and Promotion Committee, Curriculum Committee, and many others. Although junior faculty can participate in faculty council committees such as the Language Goal Team or the Library Committee, this is somewhat rare.

Interactions with industrial and professional practitioners. Many faculty members are actively engaged in interactions with practitioners. This is also described in more detail in Criterion 2 in the section entitled "Direct Interactions with Constituencies." Some of these activities occur under the venue of outreach activities, including field trips, student internships, faculty and student research, the student chapter of the AIChE, and enrollment of our instructors in civilian graduate school programs, all of which are organized, advised, and mentored directly by the faculty. Internships, known locally as Academic Individual Advanced Development (AIAD), allow students the opportunity to spend part of the summer at one of a number of industrial, government, or Department of Defense Department (DoD) facilities around the world. These internships are arranged by the faculty by direct interaction with the sponsors at the host organization. This usually involves direct coordination with the technical personnel that work with the cadets. In some cases, AIADs are arranged as off-shoots of faculty research programs. There are many examples of ongoing chemical engineering or closely related projects in the department. As discussed in Criterion 2, some of the recent projects include: production of syngas from biofuels for distributed energy production, in collaboration with the DoD's Strategic Environmental Research and Development Program (SERDP) and SUNY Cobbleskill; Development of high-nitrogen energetic military pyrotechnics, in collaboration with the pyrotechnics Technology and Prototyping Division at Picatinny Arsenal; and Development and optimization of microbial fuel cells in collaboration with the Army Research Laboratory in Adelphi, MD. There are many other examples of ongoing research projects that are direct collaborations with outside agencies and companies, and many of them will be on display as posters during the accreditation visit.

D. Professional Development.

West Point faculty members typically follow a standard academic career trajectory, with academic promotions contingent on career development in teaching, scholarship, and academy service. West Point is somewhat different from other academic institutions in that academic promotions also require demonstrated accomplishments in development of junior faculty and cadets. The procedures and guidelines for academic promotions are described in DPOM 5-3, "Procedures for Awarding Academic Titles." While these procedures and titles apply to both civilian and military faculty, they are particularly relevant for civilians since continuation of appointment and salary ranges for civilians are determined by academic promotions. Military officers can continue to advance in military rank without achieving academic promotion but are strongly encouraged to pursue this opportunity.

Faculty members are active in numerous professional development activities. Local professional development opportunities exist and are described below. Faculty members present scholarly work at professional society conferences. Additionally, many faculty members support professional society conferences by participating as an organizer, session chair, and/or paper reviewer. Others serve as reviewers for journal publications. Professional development of the junior faculty is enhanced by summer faculty training workshops run by the senior faculty. Professional development is also part of the professional rating system, described in detail below.

Faculty development begins with our newest faculty members as soon as they arrive. Each department is required to conduct a new instructor training experience. These workshops help to ensure new faculty members are prepared to teach. New faculty members arrive in June and the courses begin almost as soon as they arrive and typically run through the end of July. These workshops provide the foundation for principles of effective teaching, learning styles, class organization, instructional technology, communications skills, and classroom assessment techniques. Seasoned instructors present classes to emphasize department teaching standards. Each new instructor develops his/her own style, skills, and confidence by teaching multiple practice classes from the course he/she will teach the first semester, in front of more seasoned faculty mentors. By the end of the workshop, new instructors will have presented many lessons from the course they will eventually teach to cadets and will have been mentored by senior faculty in the department. The workshop also introduces new faculty to the Academy's governance structure, the curriculum, the advising system, and the ABET criteria and process. Supervised by the members of the permanent faculty, this summer workshop is the major mechanism for maintaining the quality of our teaching.

It should also be pointed out that during the entire time they are at USMA, the junior rotating faculty work under the close mentorship and supervision of the senior faculty members. During the academic term, this involves practice lessons, classroom visits, exam and project review, and joint development of student projects. This relationship is similar in many ways to universities with Ph.D. programs, where graduate students are mentored by the university faculty. The relationships often develop into publications and presentations at national meetings. The mentorship/supervisory relationship also ensures that the junior rotating faculty are receiving continuous feedback on their classroom activities.

Junior faculty members are strongly encouraged to participate in the various programs offered by the Center for Faculty Excellence at West Point (CFE). The web site can be found at https://www.westpoint.edu/centers-and-research. The center offers a Master Teacher Program, faculty development workshops, a newsletter, and Brown Bag Sessions. The center also sponsors the Apgar Award for Excellence in Teaching. The Brown Bag Sessions are designed to be a time for faculty from a variety of disciplines to learn about and discuss topics related to teaching and learning. The workshops are conducted about once a year by outside invited speakers, and recent topics include integrated course design and assessing teaching. The Master Teacher Program is one of the primary activities of the CFE. This interdisciplinary, two-year program culminates in the award of a Master Teacher Certificate. The program develops the competencies and skills of USMA faculty members. As described on the CFE website, the program uses monthly sessions, formative review of classroom teaching, and reflective activities, to provide participants with:

- a pedagogical framework that will provide a basis for planning, implementing, and reflecting on their teaching and learning activities,
- a repertoire of skills that will allow participants to operate in a variety of different teaching situations,
- the ability to review and assess their teaching critically and revise it appropriately,
- techniques for helping learners acquire important discipline-related skills and knowledge, and
- the ability to assess students' learning throughout the program of instruction.

Faculty members attend professional conferences throughout the year and are encouraged to share their scholarship at these conferences. Many resources are available for professional and scholarly development. Faculty members can use the Dean's Reserve Gift Fund (~$12,000 per year for the department) for professional development travel and individual research funding. Faculty members may also use the cadet educational travel funds if the professional development is related to a cadet activity. Faculty may also, on a case-by-case basis, request funding for conference travel through the Dean’s office, which traditionally is able to fund all of these requests. Throughout the year, operational accounts can fund travel to specific short courses targeted towards course or laboratory requirements. There is no expectation for the teaching faculty to compete for resources outside the Academy, though such activity is encouraged when it contributes to professional growth. Additional resources for research and scholarship are available through the Dean’s Academic Research Division from several funding sources. Faculty proposals compete annually for these funds based on criteria as determined by ad hoc boards of faculty reviewers convened by the Associate Dean for Academic Research.

Locally, many no-cost professional development opportunities exist, such as: Center for Teaching Excellence teaching seminars and Master Teacher Program, professional development seminars sponsored by the Department and the Academy, and courses such as XE495 Topics: Advanced Technology, in which distinguished guests present information on the latest technology and developments in their fields. The Department also offers a seminar series conducted by the faculty, in which they present their current research and program. The purpose of this program is to facilitate intellectual development and collaborative research efforts.

The professional rating system, mentioned above, is used to ensure appropriate faculty development. This system is somewhat different for military and civilian faculty and is outlined separately below for each.

Military professional development milestones are generally described in DA Pam 600-3, which outlines the officer qualification requirements (primarily assignments and schooling) for each military rank, branch, and career field. In addition, officers establish a detailed professional development plan focusing on the five USMA domains of teaching, scholarship, service, faculty development, and cadet development. The rated officer and rating officer agree on the initial development plan as part of the initial counseling required by the Officer Evaluation Report (OER) system. The plan should address not only the present rating period but should also consider long range development opportunities with respect to the expected duration of the officer’s assignment to USMA. The officer and rater revise and update the plan during required OER quarterly counseling sessions. The plan addresses each of the domains as appropriate to the officer’s current academic rank and the requirements for promotion to the next higher academic rank. Evaluations generally consider progress in the established development plan as a significant component of the evaluation. The OER system is described in detail in Army Regulation 623-3 “Evaluation Reporting System,” available at the Army Publishing Directorate website (https://armypubs.army.mil/), by clicking “Publications,” then “Administrative,” then “Army Regulations.”

In addition to their OERs, Academy Professors receive periodic performance reviews by the Department Head. The performance review is focused on the officer’s professional development plan. The first performance review takes place after three years of service on the faculty at USMA. After six years of service, if the Academy Professor is promoted to Associate Professor, he or she will be reviewed every six years thereafter; if he or she is not promoted, he or she will be reviewed annually to encourage professional development in the five domains.

Civilian professional development is regulated by the Total Army Performance Evaluation System (Army Regulation 690-400), also found at https://armypubs.army.mil/ (in “Publications,” “Administrative,” then “Army Regulations”). The overall process is managed by the Dean’s staff, but the ratings themselves are done at the department level. This system requires an annual appraisal of faculty contributions in each of the five domains, along with periodic counseling sessions held 2 or 3 times a year. In this system, the faculty member is required to produce a detailed Individual Development Plan. The plan emphasizes discussion and joint decisions by the faculty member and the rater, with input from mentor(s), on the specific developmental experiences necessary to fulfill the mutual goals of individual career development and organizational enhancement. Each plan is uniquely tailored to the needs of the individual. The civilian faculty and rater should revise and update the plan as required. In addition to the plan, a yearly evaluation is required for each faculty member. As with the OER system for military officers, the civilian faculty member and rater should establish the yearly objectives at the beginning of the rating period. Due to the importance of the academic promotion process for civilians, the development, assessment, and revision of Individual Development Plans should focus on encouraging the faculty member to achieve the milestones and credentials necessary for the academic promotion process.

E. Authority and Responsibility of the Faculty.

Leadership Responsibilities

The Chemical Engineering Program Director has overall leadership and management responsibilities for the chemical engineering program. The program director and the chemical engineering faculty in the Department of Chemistry and Life Science are collectively responsible for program assessment. Program assessment data are collected and disseminated by the program director, and feedback is provided by the department faculty in the form of assessment feedback surveys and discussed at faculty meetings. Program faculty members (course directors, described below) are each individually responsible for the assessment of their own courses and forwarding of program assessment data to the program director. Leadership responsibilities of the program director include:

- helping to establish and maintain a positive working environment,
- interacting with department leadership,
- interacting with program constituents at the advisory board meetings,
- assisting new faculty members to develop as teachers,
- monitoring course assessments, and
- facilitating program assessment.

Management responsibilities include performance of administrative duties in support of the faculty and program, such as:

- teaching assignments,
- civilian faculty ratings and military evaluations,
- evaluating candidates for rotating faculty positions,
- acquisition and allocation of resources, and
- chairing faculty search committees.

Authority and Responsibility of Faculty

Program faculty members play an active role in course creation, modification, and evaluation. The faculty member develops course goals, identifies pre-requisite courses, writes course objectives, develops lesson materials and evaluation methods, develops a syllabus, reviews, and recommends appropriate student texts and reference materials, and conducts an annual assessment of the course. If assessment shows that course improvements are required, the faculty member assigned to that course is responsible for bringing that assessment to the attention of the program and for implementing recommended improvements. In addition to teaching their own courses, senior faculty members have the responsibility of offering guidance to junior faculty member on course development.

Every course has a course director. In larger courses, the course director is responsible for coordinating with the other instructors in the course to ensure consistency of lesson coverage. This is very important in courses with multiple sections. The procedure varies from individual to individual, but the usual procedure is for course directors to conduct regular group meetings with the instructors, preview blocks of lessons in advance, and gather feedback from previous lessons taught. At the end of the semester, the course director prepares the course assessment to identify how well the course met its objectives and to indicate student level of achievement of student outcomes. The course assessment is an open, formal meeting attended by the program director, course director, all course instructors, and faculty invited from constituent programs in large-enrollment courses. The course director presents any recommended changes with justification.

If course assessment results in recommended changes to the Redbook, the course director is responsible for preparing the specific input for the program director, who then prepares a memorandum for the Dean's office describing required changes. The Academic Affairs and Registrar Services (AARS) division of the Office of the Dean reviews all curricular changes. This office can approve minor administrative changes, but major changes must be reviewed by the USMA Curriculum Committee. The Curriculum Committee reviews the major changes and meets to discuss them with the program representatives. The committee then recommends approval or disapproval to the USMA General Committee for final action. The overall procedure is described in detail in "DPOM 5-5 Dean's Policy and Operating Memorandum on Managing Curricular Change."

As described in detail in Criterion 4, the faculty play two critical roles in the program improvement process. First, the courses in the program are the primary means by which we impart knowledge on the students, and the courses are managed and taught by the faculty. This means that the faculty are ultimately responsible for measurement of the program's student outcomes for those outcomes that occur in their courses. This also means that faculty members contribute critical information to the program assessment process in the form of numeric assessment data. Second, faculty members are directly involved in the program-level assessment process. In this process, they are responsible for reviewing and evaluating assessment data, and for making recommendations for program improvement.

The Dean of the Academic Board at USMA plays an important role in the guidance of the program and in the program improvement. In broad terms, he or she is the director of the academic program. Specifically, the Dean and his or her staff are responsible for the maintenance of the Dean's Policy and Operating Memoranda (DPOMs). The DPOMs articulate the policies governing academic programs at USMA. Many of them have already been referenced earlier in this self-study, such as procedures for curricular changes (5-5), faculty promotions (5-3), faculty recruiting (3-19, 3-20, and 3-10), academic research (5-1), teaching awards (5-6), assessment (5-7), sabbaticals (3-9), and many other important areas. These documents are available for faculty and staff on the *internal* SharePoint site at web site at http://portal.westpoint.edu/dean/Pages/DPOMs.aspx. The DPOMs are periodically reviewed by faculty committees who then make recommendations for changes to the Dean, who ultimately approves or rejects the recommendations. The Dean also chairs the General Committee and the Academic Board, listens and provides feedback to programs at the briefings at the annual departmental Dean's R&A (Review and Analysis) meetings, and provides leadership and vision for the core academic program.

The Dean's process for interacting with the programs is articulated in DPOM 5-7 (Assessment of Student Learning in Academic Majors). In short, the process requires each program have a set of student outcomes, archive their assessment process on the Dean's SharePoint site, and submit annual executive summaries of their continuous improvement efforts. The Academic Major Assessment Council (AMAC) was established to mentor the assessment process. Also, after the annual executive summaries are submitted, they are reviewed and a summary of general strengths and areas for improvement seen across the programs is provided to the Dean and General Committee. The Dean also receives a short synopsis of each program's annual assessment efforts.

Table 6-1. Faculty Qualifications - Chemical Engineering Program, Department of Chemistry and Life Science[5]

Faculty Name	Highest Degree Earned- Field and Year	Rank [1]	Type of Academic Appointment[2] T, TT, NTT	FT or PT[3]	Years of Experience: Govt./Ind. Practice	Years of Experience: Teaching	Years of Experience: This Institution	Professional Registration/ Certification	Level of Activity[4] H, M, or L: Professional Organizations	Level of Activity: Professional Development	Level of Activity: Consulting/ summer work in industry
Armstrong, Matthew	Ph.D., Chemical Engineering, 2015	ASC	NTT	FT	24	8	8	EIT	M	H	L
Biaglow, Andrew	Ph.D., Chemical Engineering, 1993	P	T	FT	2	26	26	None	H	L	M
Bull, Geoffrey	Ph.D., Nuclear Engineering, 2013	ASC	NTT	FT	24	9	9	None	L	M	L
Burpo, John	Ph.D., Bioengineering, 2012	ASC	T-E	FT	28	10	10	EIT	H	H	L
Corrigan, Trevor	M.S., Chemical Engineering, 2018	I	NTT	FT	12	2	2	EIT	M	H	M
Cowart, Samuel	Ph.D., Chemical Engineering, 2020	AST	NTT	FT	0	3	3	None	L	M	L
James, Corey	Ph.D., Chemical Engineering, 2017	AST	TT-E	FT	21	6	6	None	H	H	M
Kowalski, Eileen	Ph.D., Chemistry, 1999	ASC	T	FT	0	19	19	None	L	H	L
Miller, April	Ph.D., Chemical Engineering, 2017	AST	NTT	FT	20	3	3	None	H	H	L
Nagelli, Enoch	Ph.D., Chemical Engineering, 2014	AST	TT	FT	3	4	4	None	H	H	L
Woronowicz, Kamil	Ph.D., Chemistry, 2005	AST	NTT	FT	0	9	4	None	M	L	M

Instructions: Complete table for each member of the faculty in the program. Add additional rows or use additional sheets if necessary.
1. Code: P = Professor; ASC = Associate Professor; AST = Assistant Professor; I = Instructor; A = Adjunct; O = Other
2. Code: T = Tenured; TT = Tenure Track; NTT = Non-Tenure-Track; T-E = Tenure equivalent; TT-E = Tenure-Track Equivalent
3. Code: FT = Full-time; PT = Part-time.
4. The level of activity (high, medium, or low) reflects an average over the year prior to the visit plus the two previous years.
5. Faculty from other departments teach chemical engineering students in program courses offered in their departments, such as Electrical Engineering and Computer Science, Civil and Mechanical Engineering, and Mathematical Sciences. Information pertaining to the qualifications of these faculty members is available in the self-studies for their respective programs and CVs are included in Appendix B.

Table 6-2. Faculty Workload Summary- Chemical Engineering Program, Department of Chemistry and Life Science[5]

Faculty Name	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to Program[5]
			Teaching	Research or Scholarship	Other[4]	
		Department of Chemistry and Life Science				
Armstrong, Matthew	FT	20-1: CH459/3.5; CH289/1.0; CH389/1.0; CH390/1.5 20-2: CH400/1.5; CH101/4.5; CH290/1.0; CH390/1.5 CH489/3.0	50%	10%	40%	75%
Biaglow, Andrew	FT	20-1: CH365/3.0 20-2: CH402/3.5	50%	30%	20%	80%
Bull, Geoffrey	FT	20-1: CH101/4.0 20-2: CH102/4.0	65%	5%	30%	50%
Burpo, John	FT	20-1: CH102/4.0; CH289/1.0; CH290/1.0; CH389/1.5 CH489/3.0 20-2: CH450/3.0; XE310/3.0, CH290/1; CH390/1.5 CH490/3.0	30%	20%	50%	15%
Corrigan, Trevor	FT	20-1: CH102/4.0; CH289/1.0; CH290/1.0 20-2: CH362/3.5; CH389/1.5	60%	30%	10%	50%
Cowart, Samuel	FT	20-1: none; new faculty arriving in AY21 20-2: none	---	---	---	---
James, Corey	FT	20-1: CH363/3.5; CH390/1.5 20-2: CH367/3.0; CH390/1.5; CH489/3.0	80%	15%	5%	90%
Kowalski, Eileen	FT	20-1: CH383/3.5 20-2: CH384/3.5	50%	10%	40%	10%
Miller, April	FT	20-1: CH485/3.5, CH289/1.0; CH290/1.0; CH489/3.0 20-2: CH101/4.0, CH289/1.0; CH489/3.0; CH490/3.0	80%	10%	10%	90%
Nagelli, Enoch	FT	20-1: CH459/3.5; CH389/1.5; CH489/3.0 20-2: CH364/3.5; CH390/1.5; CH489/3.0; CH490/3.0	65%	25%	10%	90%

Woronowicz, Kamil	FT	20-1: CH383/3.5 20-2: CH384/3.5	75%	15%	10%	10%

1. FT = Full Time Faculty or PT = Part Time Faculty, at the institution
2. For the academic year for which the self-study is being prepared.
3. Program activity distribution should be in percent of effort in the program and should total 100%.
4. Indicate sabbatical leave, etc., under "Other."
5. Out of the total time employed at the institution.

Table 6-3. Faculty Credentials, and Development Activities for Faculty in Table 6-1[b]

	AY2014	AY2020
Total Department Faculty in Program	12 (8)[a]	10 (7)[a]
Chemical Engineers	9 (4)[a]	7 (3)[a]
Nuclear Engineers	0 (0)[a]	1 (1)[a]
Bioengineers	0 (0)[a]	1 (1)[a]
Chemists	3 (3)[a]	2 (2)[a]
Faculty Holding PhD	7	9
Master Level Faculty	5	1
Professional Engineers (PE)	0	0
Engineer in Training (EIT)	1	2
Instructors	5	1
Assistant Professors	3	5
Associate Professors	3	4
Full Professors	1	1
Society Memberships	29	26
Presentations and Conference Proceedings	32	106
Journal Articles	27	54
Books	2	1
Consulting Jobs	2	2
Patents	1	2
Courses Taught Per Faculty Member	2.7	2.4
Courses Taught / Term / Faculty Member	1.3	1.2
Average Years of Teaching Experience	8.3 (13.0)[a]	9.9 (12.4)[a]

[a] Parentheses designate number of faculty with 5 or more years of teaching experience.

[b] LTC Cowart is arriving in AY2021 and is not included in this analysis

6-18

CRITERION 7. FACILITIES[1]

A. Offices, Classrooms and Laboratories

Summarize each of the program's facilities in terms of their ability to support the attainment of the student outcomes and to provide an atmosphere conducive to learning.

1. [Page 7-2] Offices (such as administrative, faculty, clerical, and teaching assistants) and any associated equipment that is typically available there.
2. [Page 7-2] Classrooms and associated equipment that are typically available where the program courses are taught.
3. [Pages 7-2 to 7-4] Laboratory facilities including those containing computers (describe available hardware and software) and the associated tools and equipment that support instruction. Include those facilities used by students in the program even if they are not dedicated to the program and state the times they are available to students. Complete Appendix C containing a listing of the major pieces of equipment used by the program in support of instruction.

B. Computing Resources

[Pages 7-4 to 7-7] Describe any computing resources (workstations, servers, storage, networks including software) in addition to those described in the laboratories in Part A, which are used by the students in the program. Include a discussion of the accessibility of university-wide computing resources available to all students via various locations such as student housing, library, student union, off-campus, etc. State the hours the various computing facilities are open to students. Assess the adequacy of the facilities to support the scholarly and professional activities of the students and faculty in the program.

C. Guidance

[Page 7-7] Describe how students in the program are provided appropriate guidance regarding the use of the tools, equipment, computing resources, and laboratories.

D. Maintenance and Upgrading of Facilities

[Pages 7-8 to 7-9] Describe the policies and procedures for maintaining and upgrading the tools, equipment, computing resources, and laboratories used by students and faculty in the program.

E. Library Services

[Pages 7-9 to 7-13] Describe and evaluate the capability of the library (or libraries) to serve the program including the adequacy of the library's technical collection relative to the needs of the program and the faculty, the adequacy of the process by which faculty may request the library to order books or subscriptions, the library's systems for locating and obtaining electronic information, and any other library services relevant to the needs of the program.

[Red font page numbers added by USMA Chemical Engineering]

[1] Include information concerning facilities at all sites where program courses are delivered.

A. Offices, Classrooms, and Laboratories.

The United States Military Academy is fortunate to have excellent facilities that enhance the abilities of Chemical Engineering students to achieve program outcomes. The Bartlett Hall complex recently completed its 250 million-dollar plus renovation which upgraded all aspects of the building including office spaces, classrooms, laboratories, and research spaces. This multi-year project has enabled the program to excel in the present and has also positioned it to excel far into the future.

1. Offices.

The offices are located for the most part in Bartlett Hall East. The Department Head and Deputy Department Head have individual offices in an office suite near a reception area, with an outer office that houses the administrative support staff. The executive officer is located in an office adjacent to the administrative area. Senior faculty members with leadership responsibilities, full professors, and associate professors have individual offices. Rotating faculty and assistant professors have office areas within a large office shared with up to three other faculty members. These offices are partitioned into three to four sections, providing separate cubicle space for each faculty member. 90% of the faculty office space is clustered on the fourth floor of Bartlett East. The remainder of faculty and staff offices are on the first floor near Thayer Roof entrance, near General Chemistry Laboratory and on the third floor in Bartlett Hall West.

The department technical staff members have offices located throughout the department, generally located near the laboratories that they service. These offices are in the Bartlett Hall North wing. For example, the Chief Chemist has an office located near the primary research laboratory on the second floor. Other technical staff have offices located near the General Chemistry Lab. The Chemical Engineering Laboratory technician office is adjacent to the Chemical Engineering classroom laboratory. The IT support staff is located adjacent to the executive officer allowing for universal support for all department IT needs.

2. Classrooms.

The vast majority of classrooms that are available are designed for a class size of approximately 16-20 students. As the number of cadets enrolled in the program extends beyond this number, we can accommodate them by increasing the number of sections in each course. As far as the physical description of the classrooms, they are painted in a soft neutral light-tan color. Windows were upgraded with inner blast protection during the Bartlett Hall renovation. Chairs and desks are easily movable to accommodate group work without leaving the room. Each room has traditional blackboards and its own "classroom technology system" that includes computer system, projector, and wireless internet availability. Most classrooms are also equipped with a lab bench which allows for in-class demonstrations. Benches are typically equipped house air and natural gas lines, an assortment of commonly used glassware and chemical storage cabinets. Computer-modeling-based classes are taught in rooms with individual computers loaded with the appropriate software to facilitate learning.

3. Laboratories.

All students in the Chemical Engineering program have a full eight-semester laboratory experience embedded in their programs. It begins in the core curriculum laboratory courses in chemistry and physics during the freshman and sophomore years and continues in the upper-division program courses, ensuring laboratory exposure throughout the entire enrollment. The lab spaces are described in the following paragraphs.

General Chemistry Labs. The general chemistry laboratories are in the north wing of Bartlett Hall. There are two separate labs, Rooms 106 and 122. Room 106 is 5499 square feet and room 122 is 2243 square feet. There is also a dedicated 891 square-foot prep area (with fume hoods, lab benches, glassware washers and storage facilities), as well as 961 square feet of chemical storage space dedicated to these labs. There are 93 lab stations between the two rooms arranged on long lab benches. Each station contains assorted glassware, clamps, and other supplies for wet chemical experiments. Each station has localized exhaust. An analytical balance is shared between every two adjacent stations. Each station also contains a PC with a MicroLab interface. The PC is a Dell Optiplex 790 with a 3.1GHz dual-core CPU, 250GB hard disk, and 4GB of RAM, and the PC is connected to the local network. The MicroLab interface contains a pH meter, barometer, temperature sensors, voltmeter, ammeter, timers, and a spectrophotometer. The MicroLab interface allows the lab experiments to be highly automated, and allows us to perform more work in the 2-hour lab period than would otherwise be possible. The south wing contains 32 additional lab stations in four additional labs (900 square feet each). There is also a dedicated prep area to support these labs.

Organic Chemistry Labs. There are two organic chemistry labs in the north wing of Bartlett Hall, Rooms 215 and 218. The two rooms are virtually identical, occupying 2200 square feet each, and are identically equipped. There are 20 lab stations contained in fume hoods in each lab. Each station contains assorted glassware, clamps, and other supplies for organic chemistry chemical experiments. The equipment is microscale-sized which reduces cost, not only for reagents, but also waste disposal. Each room is equipped with a 90 MHz permanent magnet Anasazi NMR spectrometer, two Perkin Elmer Frontier FT-IR Spectrometers, two Gowmac 69-400-TCD gas chromatographs, and various digital and analog melting point apparatuses. Each room is also equipped with ten six-foot fume hoods. The labs are divided into two spaces for instructional and lab work. The instructional space has a computer and projector and space for about 20 students.

Physical Chemistry Lab. There is one physical chemistry lab in Bartlett Hall, Room 158, which occupies 1300 square feet. The lab contains 16 lab stations arranged on two lab benches. Each station contains assorted glassware, clamps, and other supplies for physical chemistry chemical experiments. A lab station also has a computer and MicroLab interface, similar to the General Chemistry laboratories. Each station also has access to one of sixteen Gowmac gas chromatographs, Ocean Optics UV-Vis spectrophotometer, Ocean Optics Fluorescence spectrophotometer, oscilloscope, DC power supply, function generator and common electronic components. The room is also equipped with four fume hoods and has a dedicated prep area similar to the General Chemistry laboratory.

Instrument Lab. The department houses a fully-equipped central 2000-square foot instrumentation lab that includes a wide variety of equipment for chemical analysis, including chromatography, mass spectrometry, infrared and Raman spectroscopy, NMR, X-ray diffraction and fluorescence, elemental analysis, and thermal analysis. This facility is open to all students (with supervision and proper training). This lab is frequently used by chemical engineering students and faculty for research projects. A complete list of equipment in the instrumentation lab is provided in Appendix C.

Unit Operations Lab. The unit operations lab is currently located in the Bartlett Hall Sub-basement. The lab is 2200 square feet and contains four lab benches, a fume hood, a storage closet and sinks. The benched contains drawer space for storage and compressed air and natural gas service. The lab is also equipped with 10 PCs that are used for USB-based control of various lab experiments. These computers are also available on a limited based for remote access by cadets with prior faculty approval. The PCs are essentially the same as those in the general chemistry lab, with additional chemical engineering software added. The software used in our program is described below. The major experiments in the lab are listed in Appendix C. This area also has a 200 square foot ventilated containment bay used for labs that involve extreme pressure operations. To further enable the students learning, a 300 square foot writing room is located adjacent to the primary lab space.

The Unit Operations Laboratory is very different from the other lab experiences that are offered at the Academy. In most courses at USMA, the laboratory exercises are integrated into the lecture courses. The Unit Operations Laboratory is a separate stand-alone lab course. Within the lab, the program maintains an assortment of pilot plant units and transport experiments that support the student outcomes. The stand-alone format of this course is due primarily to the complexity of the pilot plant equipment and the length of time required for the experiments. The students require considerably more time to learn how to safely and intelligently operate this equipment, and a significant amount of time is required for proper analysis of the results. The stand-alone format of the lab allows this to occur.

Specific laboratories and equipment for each course in the Chemical Engineering Program are described in Appendix C (Laboratory Equipment), which also includes those courses taken outside the department.

B. Computing Resources.

This section describes computing resources used by the students in the program in addition to those described in the laboratories in Part A, which are used by the students in the program. Include a discussion of the accessibility of university-wide computing resources available to all students via various locations such as student housing, library, student union, off-campus, etc. State the hours the various computing facilities are open to students. Assess the adequacy of the facilities to support the scholarly and professional activities of the students and faculty in the program

Laptops. The Academy determines the computing system each cadet purchases at the beginning of freshman year. Specifications for current cadets' laptop computers by graduating year are shown below for the classes of 2017 to 2020. This data was provided by the Information and Educational Technology Division (IETD).

Class year / PC Characteristic	2020	2019	2018	2017
Brand / Model	Dell Latitude 5470	Dell Latitude 5470	Dell Latitude 5470	Lenovo ThinPad X230t
Processor	Intel i7-6820HQ 2.7GHz	Intel i7-6820HQ 2.7GHz	Intel i7-6820HQ 2.7GHz	Intel i7-3520 2.9 MHz
RAM	16 GB	16 GB	16 GB	8GB
Hard Disk	512 GB M.2 SSD	512 GB M.2 SSD	512 GB M.2 SSD	320 GB
Video Card	Integrated HD Graphics 530 1920x1080	Integrated HD Graphics 530 1920x1080	Integrated HD Graphics 530 1920x1080	1366X768 12.5" HD
Network Card	Yes	Yes	Yes	Yes
Additional Media	None	None	None	DVD ROM/ CD-RW
SOUND	Yes	Yes	Yes	Yes
External Hard Drive	No	No	No	No
PDA/Other	No	No	No	No

Bartlett Hall Computer Labs (BH331 and BH341A). Several courses in our program use the computer laboratories in Bartlett Hall. These labs are maintained by the department and are openly accessible during the academic day (about 6AM to about 6PM). After-hours, cadets have access to the building and computer labs using their CAC-card (Common Access Card). The courses using the computer labs include CH362 Mass and Energy Balances, CH363 Separation Processes, CH364 Chemical Reaction Engineering, CH367 Introduction to Automatic Process Control, CH485 Heat and Mass Transfer, CH402 Chemical Engineering Process Design, and CH459 Unit Operations Lab (for classroom meetings requiring PCs). These labs are maintained by the Chemistry and Life Science Department. BH331 has 19 Workstation Computers and BH341A has 10 with the following specifications:

- System Type: Dell Optiplex 9020
- Operating System: Windows 10, 64 Bit
- Processor: Intel(R) Core(TM) i5-4570 CPU @ 3.20GHz
- Hard Drive: 500GB
- Network Adapter: 1 Gigabit
- DVD-CD ROM: HL-DT-ST DVD-ROM DTA0N

- RAM: Dual 4.0 Gigabit Modules (8GB Total) (utilizing 3GB right now)
- Audio Adapter: Integrated Digital High Definition
- Video Adapter: AMD Radeon HD 8490 / Intel Dual HD Onboard Graphic
- Monitors: Two Dell 19-inch screens, model P1913B
- Replacement Cycle: 4 years.

The chemical engineering courses use the computer labs to teach a program-level thread in computer-aided design using CHEMCAD. The topics are introduced in a structured sequence that begins with basic flowcharting, mixes, splitters, recycle, stoichiometric reactors, and component splitters in the introductory course (CH362). Usage progresses to flash, extraction, distillation, absorption and stripping in the separations course (CH363), kinetic and Gibbs reactors in reactor design (CH364), unit analysis (CH459), heat exchangers (CH485), and equipment sizing and design (CH402). The computer lab also allows us to run advanced simulator training exercises in CH400. Finally, chemical engineering benefits from use of computer programming and algebra tools such as Mathematica and Excel, the use of which is integrated and re-enforced throughout the program courses by all of the departments. A detailed list of software follows subsequently in this section.

Library Computers. In addition to the cadets' personal laptops and the Bartlett Hall computer labs, the USMA Library has additional computers available for cadet and faculty use. There are 17 general use computers and 4 computers for catalog use only. There are two copier/scanner (Xerox) units, as well as two smaller scanners that are available for general student use. There are also 3 HP printers for cadet use in the library. The computers use the same network image that is used throughout the academic areas. Generally, the purpose of the machines is to provide internet access to the library resources and a simple office productivity suite. Once they log-in via O365, they have their own profiles and can use all the standard software provided by the staff/faculty general image. During the academic year, the main library is open Monday-Thursday 7:00 AM – 11:15 PM, Friday 7:00 AM – 9 PM, Saturday 10:00 AM – 9 PM, and Sunday 10:00 AM – 11:15 PM.

Library computers are maintained under the same policies and procedures as all library staff, according to USMA-wide IETD policy, and funded with OPA money. Any additional maintenance is completed when required by the Library Systems staff, such as re-imagining to improve performance or to mitigate infections.

Servers, storage, networks. USMA provides a range of network capabilities to support academic requirements of cadets, staff and faculty including cadet recreational use in the barracks. USMA's academic computing facilities include an integrated network of servers, classroom computers, laboratory computers, faculty workstations, and student workstations. The academic network links the cadet barracks, faculty and staff offices, academic classrooms and laboratories, and the library into a single integrated computer network that is connected to the Internet. Prior to March 2020, the network capabilities at the Academy were based on the Defense Research and Engineering Network (DREN), which is a component of the Department of Defense (DoD) High Performance Computing Modernization Program. The USMA network includes both wireless coverage and physically wired connections. Cadet barracks, staff and faculty offices, computer labs, and classrooms are covered with a combination of physically wired and wireless connections. All client devices are configured with FIPS 140-2-approved ciphers to provide individual and network security. DREN access was based on two-factor authentication, which consists of the DoD certificate in the Common Access Card (CAC) and its associated Personal Identification Number (PIN). Each cadet is also provided with 2 GB of network-based storage as well as 150 MB of Exchange based email, in addition to capacity of the cadet owned laptop computer and 256 GB external hard drive for archive storage.

The network is currently undergoing modifications which should be completed by March 2020. USMA DREN is currently being upgraded to the West Point Research and Education Network (WREN) which includes updating the wireless coverage to cadet rooms and additional areas such as the Gyms, training areas and athletic fields. This includes software to connect other user owned devices (for USMA personnel and visitors) used in support of the academic mission to the WREN. With this transition USMA's smaller-scaled DS3 commercial network to support academic researchers and requirements that can't be accomplished on the DREN will no longer be needed.

Software. USMA is fortunate to have a wide array of software available to cadets and faculty. The software is more than adequate to support student activities and the scholarly and professional activities of the faculty in the program. Each USMA Plebe computer is imaged with the following:

- Windows 10 + Office 365 64-bit
- Microsoft Edge
- Office 365
- Visio-Check on Software center
- One Note 2016
- McAfee
- MS Teams
- Active Client
- Axway
- Windows Media Player 12
- MS Project 2007-Check on software center
- Jython Environment for Students
- Python IDLE
- Python Imaging Library
- Irfan View
- Java Runtime
- Shockwave
- Adope Acrobat DC
- Smart Sync Student
- Mozilla Firefox
- IBM Lotus Forms
- ApproveIt
- Desktop Alert
- Mathematica v12.0

This suite of software is essentially the standard image for computers at USMA. It can be added to by individual programs, departments, and faculty. Faculty computers are updated about every five years, so there may be some differences in the versions, and the IT staff updates the image annually in response to department needs. In chemical engineering, addition software is available to cadets and is installed on lab computers. This includes

- Mathematica 12.0
- CHEMCAD 7.1.6
- Aspen Process Modeling 12.1 (including HYSYS and Aspen Plus)
- ChemDraw 16.0
- Matlab 2019a

C. Guidance.

Instruction on the use of tools, equipment, computing resources, and laboratories is conducted by the course director and his or her instructors (in larger courses). In larger courses such as general chemistry, this instruction is in the form of briefings to the entire section, followed by guided usage in the lab. In advanced courses such as organic chemistry and unit operations lab, this instruction is in the form of assigned readings, followed by guided usage in the lab. The lab tech and instructor are present at all times to monitor and ensure appropriate student usage of equipment and to answer questions as needed. Students cannot access the labs without the lab tech or instructor present.

D. Maintenance and Upgrading of Facilities.

Maintenance. We have the technical staff exercise the lab equipment to perform routine maintenance. Each pilot plant unit used in our program is routinely started up and given a thorough shakedown by the technical staff (Mr. Abhilash Mathew). Lab notebooks maintained by Mr. Mathew for each unit provide documentation of these exercises. Technical problems with the units are identified at that time. These normally include leaks, electrical issues, or software issues. Problems can also be identified by faculty and students during the execution of a lab.

Once a problem is identified, it must be repaired. Sometimes, the repair is simple, such as a tripped circuit breaker or a software reboot. Sometimes the required repair is more extensive. These types of problems normally require significant troubleshooting by the lab tech, who is able to work with company support teams either over the internet through support web sites or by email communications or by telephone. We occasionally require a service call by company technicians. For these types of repair, both self-repair and company visit, an estimate for the cost of the repair must be obtained.

Once we have an estimate, we coordinate with a credit card holder (there are three in the department) who then submits an electronic request in the General Fund Enterprise Business System (GFEBS). The request then goes to the Department Budget Officer for approval and then to the G8 (Resource and Management Office) for final approval. Once the electronic request is approved, the repair can be executed. Again, this might involve a self-repair or coordination of a service visit by a company representative.

The Department of Chemistry and Life Science receives an annual Supply and Maintenance (S&M) budget of $300K. These funds are used for routine repairs, maintenance, and small-scale equipment upgrade/replacement, typically less than $10K. Purchases are approved by the Program Director and Department Budget Officer. Supply purchases less than $10K can be made via credit card. Services such as routine maintenance and emergency repairs paid via credit card are limited to $2.5K. These credit card purchases can usually be completed within one week of initial request. Expenses exceeding these thresholds must be purchased via contract. Contracts are awarded through the Mission Installation Contracting Command (MICC) and can take up to four months to complete.

In addition to S&M Funds, the Department makes an annual request for additional Replacement and Upgrade (R&U) Funds from the Laboratory Resource Committee (LRC). These funds are used for life-cycle replacement of existing equipment and purchase of new capabilities, technology replacement, or increased capacity for the laboratory programs.

Individual purchases are limited to $250K, which is the limit for Operation & Maintenance, Army (OMA) Funds. These R&U purchases are subject to the same credit card limits detailed above. The LRC also maintains an emergency reserve for any unanticipated emergency repair needs for which S&M Funds are insufficient.

Upgrades. Upgrades can take the form of service lifetime replacements or identification of new technology that makes older equipment obsolete. Service lifetime replacements are programmed into the LRC process (described in Criterion 8), which is used by the Academy to secure finances from the Army for all of USMA's lab programs. This process involves identifying a service lifetime for each piece of equipment. New equipment can be purchased at that time by submitting a proposal to the LRC process. These proposals are almost always approved.

Chemical engineering pilot plants are highly modular, so a portion of the pilot plant can be upgraded without replacing the entire unit. For example, our distillation column underwent extensive renovation in 2010 through 2012. The renovation involved complete replacement of the control computer and associated process controller microcomputers. We replaced an IBM AT which was purchased in 1987 with a new computer control network based on GE/Fanuc hardware. The next phase involved upgrading the system with state-of-the-art process refractometers that are used as analyzers on the feed and product streams, as well as a state-of-the-art Coriolis flow meter and an ultrasonic level sensor on the feed tank. Since the unit is in overall excellent health, it made sense to upgrade the unit in phases. We also performed more recent but similar upgrades on our double-effect evaporator and on our gas-liquid absorption column.

Sometimes, the need for a replacement, upgrade, or new piece of equipment is identified during the course assessment, when the course director goes through and assesses lab requirements in detail. This process is described in detail in Criterion 4, and many examples of course assessments will be available for the visit team to examine.

E. Library Services.

The USMA Library has extensive historical materials reflecting the Academy's characteristics and curriculum from its founding to the present. Supporting a growing academic program, the collection has expanded and continues to develop in relevant areas and levels with access to over 1,000,000 books, documents, and serials in both physical and electronic formats. The library also supports a substantial collection of archival and manuscript records. Current hard-copy periodical subscriptions total approximately 350; over 76,000 additional titles are available in full text electronically through subscribed indexes and databases. Interlibrary loan/document delivery service can obtain copies of needed resources within forty-eight hours if necessary. In 2006, the USMA Library became a member of a statewide university library consortium known as ConnectNY. This consortium includes 15 academic institutions across New York State (including Vassar College, Rochester Institute of Technology, and Rensselaer Polytechnic Institute) that share their book and serial resources on an on-demand basis through unmediated interlibrary loan. ConnectNY provides access to 9 million titles in the collections of the participating libraries. Additionally, in 2017, priority processing of interlibrary-loan requests from the Library of Congress was established providing access to over 17 million items. During the academic year, the main library is open Monday-Thursday 7:00 AM – 10:15 PM, Friday 7:00 AM – 9 PM, Saturday 10:00 AM – 9 PM, and Sunday 10:00 AM – 10:15 PM.

Excellent access to library holdings is provided through the Library's webpage that includes links to the USMA Library online public access catalog (OPAC), digital resources, in-house restricted-access databases, and subscribed indexes and databases for electronic journals and primary sources. Online engineering-related indexes-databases-journals in the USMA library (networked throughout West Point unless otherwise indicated) include:

- AccessEngineering – Primarily book content from a broad range of essential engineering publications, including the latest editions of classics; problem-solving interactive tools. Coverage of engineering fields: bioengineering, chemical, energy, environmental, industrial, materials.
- ACS Journals A-Z – American Chemical Society publications
- Association for Computing Machinery – ACM Digital Library - Includes journals/transactions, Conference Proceedings and Technical Reports from 1969-present
- American Society of Civil Engineers (1999-present) - Portal to ASCE's publications, including 38 online journals and Conference Proceedings
- American Society of Mechanical Engineers (ASME) Journals - Portal to ASME publications. USMA Library provides select high-use titles only: Journal of Heat Transfer; Journal of Engineering for Gas Turbines and Power; Journal of Solar Energy Engineering; Journal of Mechanical Design; Journal of Biomechanical Engineering; Journal of Applied Mechanics; Journal of Engineering Materials and Technology; Journal of Energy Resources Technology
- APS Journals – Portal to American Physical Society publications
- ASTM - Individual standards ordered upon request
- Compendex (1970-present) - An engineering database that includes over 18 million records and abstracts. Indexes 5,000 international engineering sources including journal, conference, and trade publications
- Computers & Applied Sciences Complete - Indexing and some full text of periodicals in computer and other applied sciences
- DTIC Online (Defense Technical Information Center) - Citations to unclassified documents in DTIC's Technical Reports Collection, many with full text
- e-EROS : Encyclopedia of Reagents for Organic Synthesis - Database of about 70,000 reactions and 4500 of the most frequently consulted reagents.
- Environment Complete - Citations and abstracts for publications in a wide range of environmental sciences, many with full text
- IEEE Xplore (Release 2.3) - Journals, magazines, transactions, letters and proceedings online (1988-present); standards (1948-present); IET journals, letters, magazines, and conference proceedings (1988-present); IEEE books since 1974
- OSTI.GOV - contains over 70 years of energy-related research results and citations collected by OSTI. It includes journal articles/accepted manuscripts and related metadata, technical reports, scientific research datasets and collections, scientific software, patents, conference and workshop papers, books and theses, and

multimedia funded by DOE through a grant, contract, cooperative agreement, or similar type of funding mechanism from the 1940s to today. Access to mostly full-text Department of Energy research and development in physics, chemistry, materials, biology, environmental cleanup, energy technologies, renewable energy, and other topics; documents are primarily from 1991 forward

- JoVE Journal of Visualized Experiments - Video Journal that publishes the leading peer-reviewed articles consisting of high-quality video demonstrations and detailed text protocols which facilitate scientific reproducibility and productivity; Science Education is used to better teach and learn key concepts and fundamental techniques at the undergraduate course level.
- Knovel Library - Reference materials in the fields of engineering and applied sciences, including chemistry and chemical engineering, plastics and rubbers, semiconductors, advanced materials, and safety, health and hygiene. *Very useful reference for chemical engineers!*
- NASA Technical Reports Server (NTRS) - Database of NASA and NACA conference papers, journal articles, meeting papers, patents, research reports, images, movies, and technical videos.
- NTIS (National Technical Information Service) - Summaries of scientific, technical, engineering, and business publications from 1964 to the present
- Optics InfoBase - Portal to Optical Society of America publications
- Scitation - Portal to journals published and distributed by the American Institute of Physics and its member societies
- ScienceDirect - A leading full-text scientific database offering all of Elsevier's more than 4,000 peer-reviewed journals and more than 28,000 books, covering the physical and social sciences, technology and medicine
- SPIE Digital Library - Portal to Society of Photo-Optical Instrumentation Engineers journals and proceedings
- U.S. Chemical Safety and Hazard Investigation Board Website - Includes accident reports and videos and recommendations for preventing future accidents
- EbscoHost, Proquest, and Lexis-Nexis - These three general subject databases include thousands of abstracts and full-text journal articles, many in technical and scientific disciplines

The staff of 40 professional, technical, clerical, and other support personnel provides reference, research, and instructional services to cadets, faculty, and external researchers and the necessary and pre-requisite cataloging, systems, and collection development operations. Historical materials comprise a valuable library resource for many military and civilian scholars. Reference librarians perform liaison service with the Departments of Civil and Mechanical Engineering, Chemistry and Life Science, Electrical Engineering and Computer Science, Geography and Environmental Engineering, Mathematical Sciences, Physics, and Systems Engineering. LibGuides, librarian-created research guides, enhance access to Library resources and provide subject and course-level assistance for research to our patrons. These guides can be found on the USMA Library website, and often reflect collaboration between Academic Department liaison librarians and their faculty counterparts.

The library building (Jefferson Hall) opened in August of 2008. Prior to that, the library occupied the north wing of Bartlett Hall. The facility has been very well-received. It was ranked #3 in the Princeton Review College Rankings for Best Library in 2018, which is based primarily on student polling. USMA Library has been named FEDLINK's Federal Library of the Year for 2018 (for large libraries with 11 or more staff). This award recognizes the outstanding, innovative, and sustained achievements and services to our cadets, faculty, and staff. The facility is approximately 147,000 square feet. Of that area, library uses comprise approximately 134,100 square feet; the Center for Enhanced Performance (CEP) has approximately 11,100 square feet; and the Institute for Innovation and Development (IID) occupies approximately 1800 square feet. The Special Collections and Archives Division resides in a specially designed collection space on the fourth floor of Bartlett Hall, occupying approximately 23,200 square feet of the renovated building.

The library is critical to the chemical engineering program, particularly the process design course. In addition to the ACS and Elsevier journals mentioned above, the library also provides online access to:

- Kirk-Othmer Encyclopedia of Chemical Technology
- Encyclopedia of Chemical Processing
- Encyclopedia of Industrial Biotechnology
- Ullmann's Encyclopedia of Industrial Chemistry
- SciFinder (Chemical Abstracts service)
- CRC Handbook of Chemistry and Physics
- Bretherick's Handbook of Reactive Chemical Hazards eBook through Knovel
- Van Nostrand's Scientific Encyclopedia
- Encyclopedia of Computational Chemistry
- Numerous chemical engineering eBooks through Knovel AccessEngineering and Wiley

Some key chemical engineering print references available in the library include:

- *Ullmann's Encyclopedia of Industrial Chemistry* TP9.U57 2003
- *Riegel's Handbook of Industrial Chemistry* 10th ed, TP145.R53 2003
- *Bretherick's Handbook of Reactive Chemical Hazards* T55.3.H3.B73 1999
- *Chemical Processing Handbook* by John J. McKetta TP151.C573 1993
- *Standard Handbook of Hazardous Waste Treatment and Disposal* by Harry M. Freeman, TD1032.S73 1998.
- *Perry's Chemical Engineer's Handbook* TP151.P45 2008 (also available electronically through AccessEngineering).
- *The Yaws Handbook of Thermodynamic Properties for Hydrocarbons and Chemicals*, by Carl L. Yaws, QD305.H5 Y39 2006. Also available as eBook through Knovel
- *The Yaws Handbook of Vapor Pressure, by Carl L. Yaws*, QD533.Y39 2007. Also available as eBook through Knovel
- *The Yaws Handbook of Properties for Environmental and Green Engineering: Absorption Capacity, Water Solubility, Henry's Law Constants*, by Carl L. Yaws, TP200.Y394 2008.

- *The Yaws Handbook of Physical Properties for Hydrocarbons and Chemicals*, by Carl L. Yaws, TP200.Y39 2005 Also available as eBook through Knovel
- *Handbook of Thermodynamic Diagrams*, by Carl L. Yaws, QD504.Y36 1996
- *Handbook of Transport Property Data*, by Carl L. Yaws, TP156.T7 Y39 1995

The chemical engineering program works closely with the library to ensure that the library knows which services are required. A library work statement was created in 2012 to address these concerns, and the statement contains a list of specific services that are required. This document is available at the request of the ABET visit team.

The USMA Library Committee conducted a faculty survey in 2017 (surveys are conducted every 4 years) to assess the capability of the library to serve the various programs at USMA. The survey contained questions designed to assess the adequacy of the library's technical collection relative to the needs of the programs and the faculty, the adequacy of the process by which faculty may request the library to order books or subscriptions, and the library's systems for locating and obtaining electronic information. There were 85 faculty responses.

CRITERION 8. INSTITUTIONAL SUPPORT

A. Leadership

[Page 8-2] Describe the leadership of the program and discuss its adequacy to ensure the quality and continuity of the program and how the leadership is involved in decisions that affect the program.

B. Program Budget and Financial Support

1. [Pages 8-2 to 8-7] Describe the process used to establish the program's budget and provide evidence of continuity of institutional support for the program. Include the sources of financial support including both permanent (recurring) and temporary (one-time) funds.
2. [Page 8-7] Describe how teaching is supported by the institution in terms of graders, teaching assistants, teaching workshops, etc.
3. [Pages 8-7 to 8-8] To the extent not described above, describe how resources are provided to acquire, maintain, and upgrade the infrastructures, facilities, and equipment used in the program.
4. [Page 8-8] Assess the adequacy of the resources described in this section with respect to the students in the program being able to attain the student outcomes.

C. Staffing

[Pages 8-8 to 8-11] Describe the adequacy of the staff (administrative, instructional, and technical) and institutional services provided to the program. Discuss methods used to retain and train staff.

D. Faculty Hiring and Retention

1. [Pages 8-11 to 8-15] Describe the process for hiring of new faculty.
2. [Pages 8-15 to 8-17] Describe strategies used to retain current qualified faculty.

E. Support of Faculty Professional Development

[Pages 8-17 to 8-20] Describe the adequacy of support for faculty professional development, how such activities such as sabbaticals, travel, workshops, seminars, etc., are planned and supported.

[Red font page numbers added by USMA Chemical Engineering]

A. Leadership

The Head of the Department of Chemistry and Life Science has overall leadership and management responsibilities for all of the programs in the department. The chemical engineering program director is responsible for managing the chemical engineering program and reports to the Department Head. The program director provides resourcing recommendations to the Department Head, including teaching assignments, staff assignments, capital equipment purchases, and supplies.

Course directors, described on page 6-13, are each individually responsible for the assessment of their own courses and forwarding the program assessment data to the program director. Program assessment data are collected and disseminated by the program director, and feedback is provided by the department faculty in the form of assessment feedback surveys. Part of the assessment is to provide recommendations for resources for the courses. That is, the faculty members request the resources and the program director is responsible for finding the resources. The program director uses the course and program assessment data to generate and submit proposals for major pieces of equipment, upgrades to equipment, and curriculum changes.

As indicated by the accomplishments listed below, the program leadership is adequate to ensure the quality and continuity of the program. During the past ten years, the program has overseen:

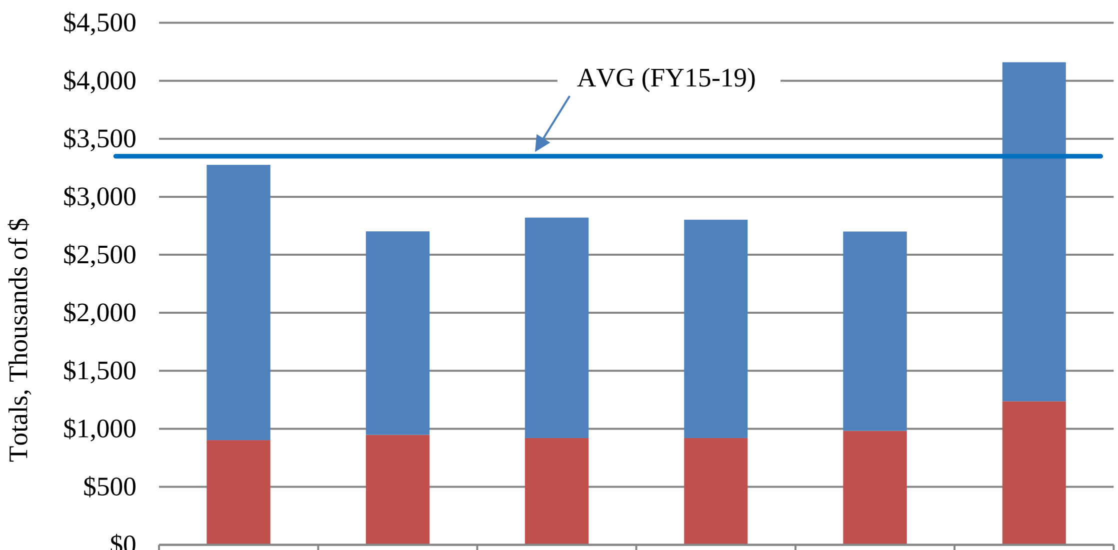
- An increase in student enrollment from 3 to 31 students,
- An increase in department chemical engineering faculty from 4 to 9,
- An increase in the number of chemical engineering courses from 5 to 9,
- The establishment of an active AIChE student chapter,
- The establishment of a wide variety of student internships for chemical engineers,
- Upgrades, refurbishment or replacement of all major equipment in the chemical engineering lab, including addition of automatic process control instrumentation on the absorption, distillation, and evaporator pilot plants, addition of a new hydrogen fuel cell stack, and new Armfield batch and CSTR units.
- The design, construction, and commissioning of a new unit operations lab,
- The acquisition of a chemical engineering lab technician, and
- The establishment of an advisory board.

Each of these activities has involved significant interactions at the institutional level to secure financial resources, and we have been very successful in these efforts. We feel that this track record provides adequate evidence that the quality and continuity of the program will be ensured for the foreseeable future.

B. Program Budget and Financial Support

1. Process used to establish the program's budget and evidence of continuity of institutional support for the program.

The receipt of appropriated fund allocations is tied to USMA's participation in the Army resource allocation processes, in particular, the Army Planning, Programming, Budgeting and Execution System (PPBES), a subset of the Department of Defense Planning, Programming, and Budgeting System (PPBS). The PPBES, as supplemented by local policies, represents the major body of procedures for the resource management process at USMA. Thus, USMA participates in the development of the Army six-year strategic plan, the Program Objective Memorandum (POM). USMA develops and submits its own POM consistent with guidance it receives from the Department of the Army headquarters. By process, the POM is a blueprint for the annual budget the Army submits to the Office of the Secretary of Defense (OSD) and that OSD submits to Congress as part of the President's budget. Much like other Army elements, USMA receives careful scrutiny during the Congressional review of the Army budget and must depend on those annual authorizations and appropriations the Army receives from Congress to receive its own allocations at the beginning of each fiscal year. Within this process, the USMA Superintendent is the Chief Financial Officer for USMA. As a federal entity, USMA's fiscal year begins on 1 October and ends on 30 September. Total non-pay expenditures since the last ABET visit in 2014 are shown in Figure 8-1 and Table 8-1 shows the allocations broken down by department for departments with ABET programs and core science courses. Figure 8-2 and Table 8-2 are analogous to Figure 8-1 and Table 8-1 but showing the actual or obligated funding as well as funding for non-pay department operations. Actual expenditures for the chemical engineering program for fiscal years 2017-2019 are shown in Table 8.3.



	FY15	FY16	FY17	FY18	FY19	FY20
R&U	$2,373.4	$1,754.3	$1,900.2	$1,881.8	$1,719.2	$2,922.1
S&M	$901.9	$947.7	$920.7	$920.7	$981.7	$1,237.0

Figure 8-1. Total Laboratory Resources Committee (LRC) allocations of non-pay funding in support of departments with ABET programs and core science courses. R&U denotes equipment replacement and upgrade and S&M denotes lab supply and maintenance. FY20 is projected.

Table 8-1. Laboratory Resources Committee (LRC) allocations of non-pay funding in support of departments with ABET programs and core science courses. Amounts are in thousands of dollars. R&U[2] denotes equipment replacement and upgrade. S&M[3] denotes lab supply and maintenance.

		FY15	FY16	FY17	FY18	FY19	FY20[1]	AVG (FY15-19)
Chemistry & Life Science	R&U	299.5	169.4	167.0	130.1	115.0	318.2	176.2
	S&M	198.0	199.0	199.0	199.0	250.0	300.0	209.0
	Total[4]	497.5	368.4	366.0	329.1	365.0	618.2	385.2
Civil & Mechanical Engineering	R&U	343.0	346.0	625.0	600.0	250.0	417.5	432.8
	S&M	226.0	240.0	240.0	240.0	240.0	298.0	237.2
	Total	569.0	586.0	865.0	840.0	490.0	715.5	670.0
Electrical Engineering & Computer Science	R&U	749.2	817.0	484.5	424.5	476.5	1,276.5	590.3
	S&M	219.2	250.0	250.0	250.0	250.0	320.0	243.8
	Total	968.4	1,067.0	734.5	674.5	726.5	1,596.5	834.2
Geography & Environmental Engineering	R&U	380.0	211.5	260.0	315.0	363.5	396.8	306.0
	S&M	107.0	107.0	120.0	120.0	120.0	144.0	114.8
	Total	487.0	318.5	380.0	435.0	483.5	540.8	420.8
Physics & Nuclear Engineering	R&U	230.7	47.4	140.7	56.6	209.2	39.1	136.9
	S&M	61.7	61.7	61.7	61.7	61.7	103.0	61.7
	Total	292.4	109.1	202.4	118.3	270.9	142.1	198.0
Systems Engineering	R&U	371.0	163.0	223.0	355.6	305.0	474.0	283.5
	S&M	90.0	90.0	50.0	50.0	60.0	72.0	68.0
	Total	461.0	253.0	273.0	405.6	365.0	546.0	351.5
Total	R&U	2,373.4	1,754.3	1,900.2	1,881.8	1,719.2	2,922.1	1,925.8
	S&M	901.9	947.7	920.7	920.7	981.7	1,237.0	934.5
	Total	3275.3	2,702.0	2,820.9	2,802.5	2,700.9	4,159.1	2,860.3

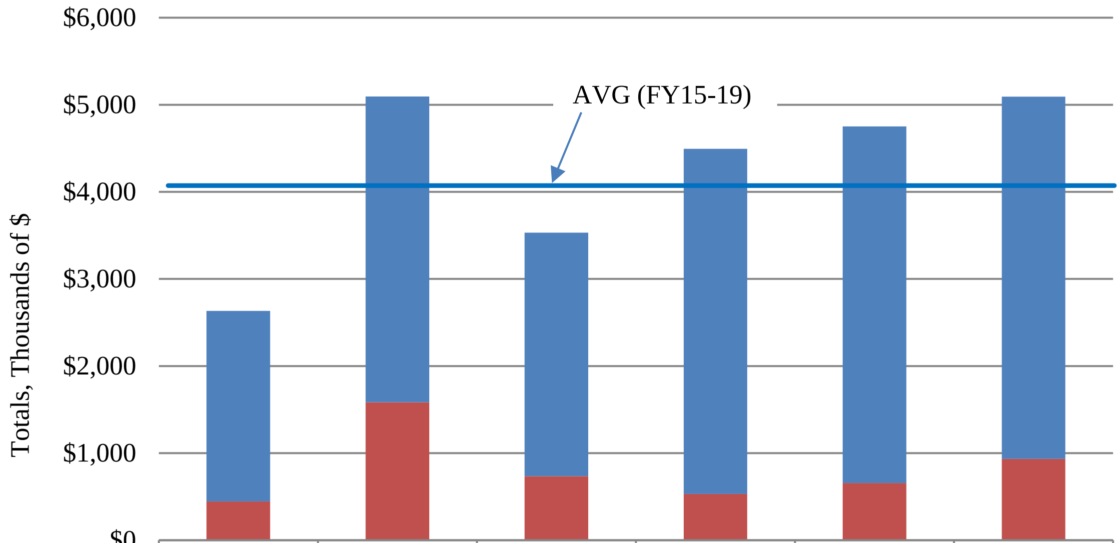
[1] West Point uses the Federal Government Schedule: Fiscal Year 2020 is from 1 October 2019 thru 30 Sep 2020. FY20 data is projected.

[2] R&U that supports the undergraduate teaching mission and does not include equipment primarily used for research. Institutional R&U funds do not include equipment that Departments have funded via the Military Interdepartmental Purchase Requests (MIPRs) or using Gift Funds.

[3] S&M funds include expendables and software licenses

[4] The values in this table and shown in Figure 8-1 are the sum of allocated R&U and S&M funds by the LRC and do not include end-of-year funding augmentation from re-allocation of unexpended Dept. of the Army and USMA funds. Actual support received (obligated) is shown in Figure 8-2 and Table 8-2.

.



	FY15	FY16	FY17	FY18	FY19	FY20
LRC	$2,187.6	$3,511.4	$2,796.8	$3,961.6	$4,095.0	$4,159.1
Ops	$446.1	$1,584.5	$734.8	$531.9	$657.2	$933.7

Figure 8-2. Total obligated non-pay funding to support laboratories and operations for departments with ABET programs and core science courses. FY20 is projected

Table 8-2. Obligated non-pay funding to support laboratories and operations for departments with ABET programs and core science courses.

		FY15	FY16	FY17	FY18	FY19	FY20[1]	AVG (FY15-19)
Chemistry & Life Science	R&U	296.2	886.6	477.8	1,217.0	650.0	618.2	705.5
	S&M	73.3	221.7	250.9	180.3	143.5	142.1	173.9
	Total[4]	369.5	1,108.3	728.7	1,397.3	793.4	760.3	879.5
Civil & Mechanical Engineering	R&U	276.0	572.0	1,081.4	799.7	741.6	715.5	694.1
	S&M	80.2	255.6	130.3	73.9	132.1	216.3	134.4
	Total	356.3	827.6	1,211.7	873.6	873.7	931.8	828.6
Electrical Engineering & Computer Science	R&U	635.4	1,380.5	386.4	670.5	1,513.6	1,596.5	917.3
	S&M	61.9	671.7	120.0	78.5	126.6	86.9	211.8
	Total	697.3	2,052.2	506.5	749.0	1,640.2	1,683.4	1,129.0
Geography & Environmental Engineering	R&U	411.3	330.0	381.3	407.7	620.3	540.8	430.1
	S&M	112.7	210.5	84.5	31.8	56.2	168.6	99.1
	Total	524.0	540.5	465.8	439.5	676.6	709.4	529.3
Physics & Nuclear Engineering	R&U	243.1	112.9	202.7	565.8	248.9	142.1	274.7
	S&M	68.6	115.3	66.2	67.4	84.2	156.0	80.3
	Total	311.7	228.2	268.8	633.2	333.2	298.1	355.0
Systems Engineering	R&U	325.5	229.4	267.2	300.9	320.6	546.0	288.7
	S&M	49.5	109.6	82.9	100.0	114.6	163.8	91.3
	Total	374.9	339.0	350.1	400.9	435.2	709.8	380.0
Total	R&U	2,187.6	3,511.4	2,796.8	3,961.6	4,095.0	4,159.1	3,310.5
	S&M	446.1	1,584.5	734.8	531.9	657.2	933.7	790.9
	Total	2,633.7	5,095.8	3,531.6	4,493.5	4,752.3	5,092.8	4,101.4

[1] West Point uses the Federal Government Schedule: Fiscal Year 2020 is from 1 October 2019 thru 30 Sep 2020. Numbers shown here for FY20 are the current fiscal year financial targets and do not include end-of-year funding augmentation from re-allocation of unexpended Dept. of the Army and USMA funds. The average has been 15% additional funding during FY15-19 for LRC funding of laboratories.

[2] LRC includes the actual amount of funding obligated towards laboratory R&U and S&M to include end-of-year supplemental funds, and so will differ from the values in Figure 8-1 and Table 8-1 which were allocated by the Laboratory Resources Committee. These funding categories are defined under Table 8-1.

[3] Ops include non-pay departmental operating expenses, including faculty travel funds.

Table 8-3. Support Expenditures for the Chemical Engineering Program.

Fiscal Year / *Expenditure Category*	*FY2017*	*FY2018*	*FY2019*
Operations (not including staff pay)			
(a) Institutional Funds	$0	$40,000	$119,000
(b) Grants and Gifts	$2,500	$4,900	$7,029
(c) Research Funds (MIPRs)	$0	$0	$148,969
Travel			
(a) Institutional Funds	$17,013	$23,822	$9,098
(b) Grants and Gifts	$34,027	$41,290	$40,905
(c) Research Funds (MIPRs)	$39,996	$24,000	$55,992
Equipment			
(a) Institutional Funds	$98,250	27,334	$96,629
(b) Grants and Gifts	$0	$0	$0
(c) Research Funds (MIPRs)	$0	$0	$0

2. Support of teaching in terms of graders, teaching assistants, teaching workshops, etc.

Graders and teaching assistants are not available at USMA. All grading and teaching functions are performed by USMA faculty. Teaching workshops are described in Criterion 6, pages 6-9 to 6-10.

3. Processes for obtaining resources for acquisition, maintenance, and upgrading of program infrastructure, facilities, and equipment.

The chemical engineering program receives most of its support through the academy's laboratory equipment planning, acquisition, and maintenance processes. In our program, in conjunction with the annual course assessments, course directors identify any new laboratory equipment or equipment upgrades required, identify any laboratory equipment no longer needed, identify recurring maintenance requirements, and rate the current status of the laboratory equipment as green (fully capable), amber (degraded capability), red (program failure pending), or black (program failure now). In late spring the department consolidates and submits the request for laboratory funding to the Laboratory Resources Committee (LRC) whose responsibilities are described in *Dean's Policy and Operating Memorandum 3-18*. The request includes requirements for both new equipment and maintenance for the upcoming fiscal year and projects new equipment requirements (based on equipment life cycle/projected new courses) for the following fiscal year. In September, the LRC prioritizes departments' requirements into the Academic Laboratory Resources Plan under two categories: Supply and Maintenance Account and Equipment Account. Upon receipt of the budget at the beginning of the fiscal year (1 October), the LRC allocates funds to departments based on the prioritized requirements. For items not funded, the LRC develops a list of unfinanced requirements. Should the Academy receive additional allocation of funds at mid-year or at fiscal year end, the LRC may be able to fund these unfinanced requirements.

Once it receives an allocation, the department can initiate procurement procedures. The department first must obtain any required authorizations (Capabilities Requirement for automation, communications, visual information, records management, printing, and publications; Table of Distribution and Allowance Approval for any item not on the Common Table of Allowances; and Energy Approval for an item that consumes electrical energy from post power facilities). Once approvals are obtained, the department can requisition equipment. Equipment purchases less than $5,000 can be ordered on the department's credit card while equipment purchases greater than or equal to $5,000 must be procured through the Director of Contracting. The credit card limit on service awards is $2,500 before contracts must be awarded by the Director of Contracting.

The department executes scheduled maintenance as required. The LRC allocates funds to an Insurance Account as an emergency repair fund. Should it require emergency repair of equipment, the department can request funds from the Insurance Account to expedite the repair.

4. Adequacy of resources.

We have been very fortunate to have had excellent financial resources over the past decade. Beyond the student outcomes, our curriculum is enriched by a series of funded student internships and research grants. Our laboratories are newly rebuilt, and our laboratory equipment is all in top working condition. We see no need for additional financial resources beyond where we are currently.

C. Staffing

Adequacy of the Staff. The staff members are highly trained, very competent, have many years of experience in the institution, and meet the needs of the chemical engineering program. Each of the department staff members, along with their job title, government job code, pay level, and years of experience, are listed in Table 8-4. The department faculty members are comfortable with the support provided by the staff, both in the administrative and lab support areas.

Table 8-4. Support Staff.

Name	Title	Occupational Code & Level	Years at USMA
Mrs. Sharon Moran	Administrative Officer	GS-0341-11	40
Mrs. Kristen Costain	Administrative Support Assistant	GS-0326-6	22
Mr. Lance Richardson	Laboratory Program Director	AD1701 Title 10	
Vacant	Microbiologist	GS-0403-12	13
Mr. Victor Garza	Chemist	GS-1320-11	10
Mr. Marz Garcia	IT Specialist	GS-2200-11	18

Mr. Manuel Treus	Physical Science Technician	GS-1311-10	22
Vacant	Administrative Support Assistant, (Supply)	GS-0326-6	
Mr. Brian Dorn	Physical Science Technician	GS-1311-9	6
Mr. Abhilash Mathew	Chemical Engineer	GS-0893-11	5
Mr. Devin DiPierro	Biology Technician	GS-0404-7	2
Mr. Abdul Rasheed	IT Specialist	GS-2200-11	9

The chemical engineering program receives support from the technical and clerical staff. Two administrative support staff provide all levels of administrative support for chemical engineering, including such items as typing support, assistance with academy rules and regulations, maintenance of the salary database, assistance with travel for students and faculty, and many other duties. One lab technician is dedicated to the chemical engineering program. Formerly a contract position, this position was converted to a Title 5, GS-11, Chemical Engineer effective October 2019. Other staff members are shared by the three department programs and provide support to chemical engineering. The Laboratory Program Director (AD1701 Title 10, Mr. Richardson) is integral to our laboratory and research programs and the supervision of laboratory staff. He assists with developing contracts for purchasing new equipment and supplies and with management of the chemistry labs. The Laboratory Manager also assists chemical engineering by maintaining our equipment inventory and hand receipts. To expand the pool of qualified applicants beyond current government employees, this job was recently converted from a GS Title 5 to a Title 10 “excepted service” position. The process to convert the position was discussed after the retirement of the former Laboratory Manager in July 2018 and finalized in January 2019. The Department recruited for the position and initially received an unsatisfactory pool of candidates, but the position was re-advertised in August 2019 and a highly qualified candidate (Mr. Richardson) was eventually selected in September 2019. The IT staff (Mr. Garcia and Mr. Rasheed) provide significant software, hardware, and networking support, particularly with the computing lab and frequently with cadet laptops. They also provide assistance with critical updates on faculty computers and are an important interface to the Academy’s Chief Information Officer.

Retention and Training of Staff. Retention of highly qualified staff is dependent on pay rates, rate of increase of pay, and benefits. Department staff members are government employees, and their rate of pay is fixed by law in the General Schedule (GS) pay tables. The GS pay table is public knowledge and is readily available on the internet. There are 10 steps to each grade, and new employees begin at step 1. The timing of the step increases is as follows: Years 2, 3, and 4 have 52 weeks between each step increase for a total of three steps. There are 104 weeks between each step for years 5, 6, and 7, and for years 8, 9, and 10, there are 156 weeks between each step. After step 10 there are no more steps at that pay grade. There is virtually no promotion potential beyond the step increases. To obtain a promotion to a higher pay grade, staff members must apply for a new job, and this usually means movement to a different department or to a different organization.

Staff retention is also enhanced by a fairly robust job benefits program. The major benefits enjoyed by our staff are listed in Table 8-5. The benefits are listed in the left-hand column, and those benefits available to staff members are bulleted in the right columns. Staff benefits include a retirement pension, access to the government's Thrift Savings Plan, health and dental benefits, access to base facilities such as recreation and day care, and access to union representation. Civilian staff can be recognized for excellent performance with cash awards. The Dean's office provides an allotment of money equal to 1% of the total civilian staff salary. For the current year in the Department of Chemistry and Life Science, this allotment is $15,050. It is used for performance-based incentive bonuses awarded to department staff. Retention of government employees is also enhanced by the government tenure system, which is one of the most significant benefits of government employment.

Tenure within the government civilian workforce is a feature of "Competitive Service," which is essentially all of the civil service positions within the executive branch of the federal government. Appointments in the Competitive Service are obtained through a competitive process, and they convey status within the Federal government. After successfully completing a one-year probationary period, employees are designated as "career conditional." After three years, they are "career" employees. Perhaps the most significant benefit of being a career-status employee in the Competitive Service is the acquisition of what is known as "competitive status." Competitive status is an employee's basic eligibility for a job assignment via transfer, promotion, reassignment, demotion, or reinstatement to another position in the Competitive Service without open competition examination. Competitive status benefits also apply in reduction in force (RIF) situations, even if the employee's job is eliminated. Competitive status is obtained automatically after 3 years of substantially continuous satisfactory or higher performance of service. Once career tenure has been earned, it belongs to the employee for life, as long as performance remains at least at a satisfactory level. (See https://www.opm.gov/policy-data-oversight/hiring-information/competitive-hiring/.)

Training. All departmental staff and faculty must complete mandatory annual training of different topics such as Sexual Harassment / Assault Response & Prevention, ethics, computer awareness, and antiterrorism, among many others. Professional training for job requirements is available for staff members, who must coordinate this activity with the Administrative Officer. Money for the training must be available. The department receives an annual allotment of appropriated funding from the Department of Defense congressionally-approved budget. The amount varies from year to year depending on the available allocations. For FY 2019, the department received $17,000 for faculty and staff training (not included in Table 8-3). In addition to appropriated funding, part of the Dean's reserve gift funding (obtained from donors through the Association of Graduates) to supplement staff, faculty, and cadet travel is allocated to the Department of Chemistry and

Life Science. These gift funds roll over and do not expire at the close of the FY. Last year we received approximately $48,000 of this gift funding, some of which could potentially be used for training. Over the last five years, there has been adequate funding to accommodate all department head-approved travel and training requests. Faculty are encouraged to seek outside funding through their research initiatives in support to their conference presentations, publications, and travel. All staff are encouraged annually to enroll in at least one training course to attend in person or perform online to enhance their skills. Recent examples of staff training include classes in Microscopy, Laboratory Safety, Engraving, and SharePoint. Relevant due to the fact that the staff support the chemical engineering program.

D. Faculty Hiring and Retention

1. Process for hiring of new faculty.

The process starts with development of a Table of Distribution and Allowances (TDA), which applies to all personnel in the department, including civilian faculty and staff, as well as military faculty members. To increase positions on the TDA, the Department Head must submit a request to the Dean, Office of Personnel and Resources, the G8 resource manager to assure payroll funding exists, The West Point Chief of Staff and the final approval authority is the Army Chief of Staff. It is very difficult to add positions to the TDA as they require a guaranteed source funding to cover payroll salary and benefits which add another 30% to the cost. Changes to the payroll budget for all of West Point are approved by the Department of Defense, included in the President's Budget, and ultimately sent to Congress for final approval. The TDA for the academy and for the department is available for examination on request by the visit team.

The processes for hiring military and civilian faculty and the civilian staff are described below. The local point of contact for questions on any of these processes is Mrs. Sharon Moran.

Civilian Hiring Process. Once the position is established on the TDA as being both required and authorized, the process for filling a position is as follows:

- A request for recruitment action is forwarded to the Office of the Dean, Plans and Resources Division (PRD). The Vice Dean for Resources. His staff determines that there is a valid vacancy and funding available to recruit for the vacant position.
- Once approved by Dean's PRD, the personnel action is routed electronically to the Superintendent's Resource Manager (known in the military as the G8). The G8 approves or disapproves the recruitment action based on the TDA and the availability of funding for the hire.
- The recruitment action is then forwarded electronically to the Chief of Staff for the Superintendent, who approves or disapproves on behalf of the Superintendent. If approved, the recruitment action is forwarded to the Civilian Personnel Advisory Center (CPAC).
- CPAC contacts the department for a recruitment advertisement based on a department approved position description and places the recruitment advertisement

in USA Jobs. (www.usajobs.gov) The advertisement normally stays open for 10 days.

- CPAC personnel review the applications and send a list of best qualified applicants back to the department, along with their resumes or CVs. Candidates will be interviewed, a selection made and a referral list (DA2600) is returned to CPAC. Priority placement is given to qualified spouses of active duty military, to persons who were separated involuntarily due to a reduction in force (RIF), or whose job was abolished due to a managerial realignment or attrition.
- CPAC will present the official notification of selection and the start date of employment. For civilian staff, the initial screening happens at CPAC and is not under our control.
- For civilian faculty, the process differs at this point from that for civilian staff. The difference is that CVs are sent back to the department for a selection committee to screen based on program-level criteria. Interviews are conducted, selections are made, and the outcome presented to the Head of the Department. All candidate files and the selection matrix are forwarded to an HR specialist at the Civilian Personnel Advisory Center. The HR specialist will assign extra credits for veterans, military spouses, or Federal employees with a hiring priority. The list of applicants (or CVs) for civilians is screened at the department level by a hiring committee, and the committee makes a recommendation to the Department Head. Once the Department Head concurs, CPAC is notified of the selection. A memo detailing the selection process followed and the chosen candidate is forwarded to the Dean of the Academic Board along with the candidate's transcripts. If the Dean agrees with the selection committee, the memo is then forwarded to the Civilian Personnel Advisory Center and an HR specialist presents an offer to the best candidate. If the candidate accepts the offer, an in-depth background check begins. Upon conclusion of the background check, an entry on duty date is established for the new employee.
- Veterans get preference points depending on when they served in the armed forces and whether or not they were disabled or wounded (no points for retired military).

Rotating Military Faculty. The process is described in detail in DPOM 3-10, "USMA Military Rotating Faculty Selection." This DPOM describes academy-level features of the process. There are some aspects of this process that are specific to our department. The detailed department-specific process, as well as a detailed timeline for the process, is documented in a standard operating procedure (SOP) maintained by our Faculty Recruiting Officer, who does this as an additional duty. A description of the process follows below:

- The process begins with faculty recruitment. Rotating military faculty candidates are directly recruited from the Army by the various departments at the Academy. Our department uses the Total Army Personnel Information Management System to screen for and identify suitable candidates. We also keep records on outstanding cadets and track their careers individually.
- Once identified, the faculty candidates are then encouraged to apply for positions at the Academy. Candidates apply through the Academy's Web-Enabled Selection and Tracking System (WEST).

- The WEST system allows candidates to upload GRE scores, an Officer Record Brief (ORB), Officer Evaluation Reports (OERs), the Candidate Statement, transcripts, and Army Physical Fitness Test (APFT) scores.
- Once completed, all applications are carefully reviewed by a department faculty committee.
- The top candidates are forwarded to the Army Human Resources Command (AHRC). AHRC reviews each candidate to determine if the candidate's career timeline and manner of performance merit assignment at USMA.
- The final order of merit list (OML) of AHRC-approved candidates is presented to the Department Head for final approval and selection for assignment to USMA. The West Point G1 (general-staff personnel managers) are notified and keep a record of these officers in the "Blue Book."
- Following selection, the officers attend a 24-month graduate program in an area related to the department's disciplines and teaching needs. Second-tour rotating faculty and Academy Professors attend a doctoral program for up to 36-months.

Academy Professors. The process is described in detail in DPOM 3-20, "Procedures for Selecting Academy Professors." The DPOM describes all of the features of the process, but some of these items are out of date, and the current process is described below.

- The process is initiated by the Department Head, who sends a request to the Personnel Resources Division of the Office of the Dean (PRD) to verify that the position exists in the TDA, that it is funded, and to authorize a search. The Department Head sends a proposed advertisement, recommendation for a search committee, and parameters to query the Army for qualified candidates.
- The PRD notifies the G1 of the requirement to establish the search and advertises the search on the G1 web site.
- The PRD also prepares a staff summary sheet to obtain the Dean's and Superintendent's approval for the search, to describe the composition of the search committee, and includes the advertisements.
- The Dean and Superintendent must approve the search and committee membership.
- The PRD publishes the committee orders and distributes them to the committee members.
- The AHRC notifies all eligible Army officers (Captains through Colonels) by email of the vacancy, with instructions on how to contact the committee secretary if they wish to apply.
- The committee secretary collects applications, and the committee reviews the applications to determine which candidates should be interviewed.
- After the interviews are completed, the committee provides the names of the finalists to the PRD for assessment of availability and sustainability by the AHRC.

- The committee meets with the Dean of the Academic Board to brief him or her on their selection and the process involved.
- If the Dean approves the selection and feels that the selection committee has made every effort to seek diversified, qualified, candidates, the Dean and the selection committee then brief the Superintendent on the selection. If the Superintendent agrees that the committee has performed the search to the best of their abilities and approves of their selection, the candidate(s) are then added to the Academic Board agenda for a vote to approve the candidate. If the Academic Board approves the candidate(s), the candidate is then notified of their selection. Non-selectees are also notified at that time by the Chair of the selection committee.
- PRD prepares the official nomination for the selected officer and forwards the nomination through the USMA G1 for the Army G1, who then coordinates the nomination with the AHRC and publishes orders for assignment to USMA as an Academy Professor.

Professors USMA. The process is described in detail in DPOM 3-19, "Procedures for Selecting Academy Professors." The DPOM describes all of the features of the process, but some of these items are out of date, and the current process is described below.

- The process is initiated by the Department Head, sends a request to the Personnel Resources Division of the Office of the Dean (PRD) to verify that the position exists in the TDA, that it is funded, and to authorize a search. The Department Head sends a proposed advertisement, recommendation for a search committee, and parameters to query the Army for qualified candidates.
- The PRD notifies the G1 of the requirement to search and advertises the search on the G1 web site.
- The PRD submits a request for Department of the Army representation to the G1.
- The PRD also prepares a staff summary sheet to obtain the Dean's and Superintendent's approval for the search, to describe the composition of the search committee, and includes the advertisements.
- The Dean and Superintendent must approve the search and committee membership.
- The PRD publishes the committee orders and distributes them to the committee members.
- The AHRC notifies all eligible Army officers (Captains through Colonels) by email of the vacancy, with instructions on how to contact the committee secretary if they wish to apply.
- The committee secretary collects applications, and the committee reviews the applications to determine which candidates should be interviewed.
- The committee determines that most qualified candidates to be interviewed. The number of in-person interviews is based on budget availability. Video Teleconference (VTC) interviews are encouraged.
- After the interviews are completed, the committee provides the names of the finalists to the PRD for assessment of availability and sustainability by the AHRC.

- The committee makes a recommendation to the Dean. If the Dean approves the selection, the Dean and the committee present their recommendation to the Superintendent. If the Superintendent agrees with the selection, the selection is presented to Academic Board for approval. Upon Academic Board approval, the selectee is notified. Non-selectees are notified by the committee Chair.
- PRD prepares the official nomination for the selected officer and forwards the nomination through the USMA G1 for the Army G1.
- The Army G1 coordinates the nomination as appropriate to obtain a recommendation from the President of the United States and confirmation by the United States Senate.
- The nominated officer is notified of the Senate confirmation and AHRC and publishes orders for assignment to USMA.
- The nominated officer coordinates with the USMA G1 for an official ceremony.

2. Strategies used to retain faculty.

Tenure. The faculty structure was previously described in detail in Criterion 6, pages 6-3 to 6-5. Civilian faculty members are in the excepted service, which provides a somewhat streamlined hiring process and allows the academy to more easily fill faculty positions from outside the pool of government employees. This is provides more hiring flexibility in cases where a significant number of applicants might be graduate students or post docs at civilian universities, and where they would have to compete with more advanced career professionals in the competitive service.

A system for civilian faculty Associate Professors and Professors has recently been approved by the Staff Judge Advocate and the Dean for those faculty members to receive permanent appointments upon promotion to associate professor. Faculty at these ranks were converted to permanent appointments during July and August of 2019. For civilians at the rank of assistant professor, there is a contract system that is connected to the promotion process. Assistant professors are generally given two three-year renewable contracts to allow for adequate progress toward academic promotion. Faculty retention is generally not problematic on the civilian side, and no one has been removed from the program or from the department for lack of performance. There are cases where faculty members in non-renewable contract positions have had to leave the department even though they wanted to stay. However, they were hired into non-renewable positions and renewable positions were not available at the time. Military faculty members are rotated into the department. Because of the rotation system, retention is not an issue. However, many of these faculty members return for a voluntary second rotation. Military faculty that are permanently assigned generally remain until mandatory retirement.

Promotions. Academic promotions at the USMA are consistently accomplished based on two sets of criteria: academic criteria established in Dean's Policy and Operating Memorandum (DPOM) 5-3, *Academic Titles and Appointment and Promotion Procedures*, and resource availability. Academic promotion criteria apply to both military and civilian faculty members. Qualifications for promotion to the senior faculty include evidence of excellence across the five faculty domains of teaching, scholarship, faculty development, cadet development, and service, as well as external letters of evaluation from disinterested experts. Faculty members are encouraged to maintain and submit their teaching CVs for consideration during the promotion process. Since academic promotion of military faculty entails no resource commitment, the number of military faculty who may be appointed to the senior ranks is not restricted by resources. The academic promotion of civilian faculty does entail resource commitment. The Dean or Commandant determines the number of authorized positions for civilian faculty based on available resources (authorizations/funding). In cases in which a promotion is approved but funding is not available, civilian faculty members will be granted the new academic rank without the concomitant salary increase until such time that funding becomes available. The salary will not be retroactive.

- *Assistant Professor.* The department head nominates and the Dean or Commandant approves an individual for promotion to Assistant Professor. Department Heads forward nominations for promotion or initial appointment to the Dean or Commandant by December to permit promotions and appointments to become effective by the start of the fall semester each year or prior to the nominee's permanent change of station.

- *Associate Professor.* The department head nominates, the Faculty Credentials and Promotion Committee reviews, and the Dean or Commandant recommends an individual for initial appointment or promotion. The Academic Board exercises approval authority. Department Heads forward nominations for promotion to Associate Professor through the Dean or Commandant to the Faculty Credentials and Promotion Committee by 15 January to permit promotions to become effective by the start of the fall semester each year.

- *Professor.* The department head nominates, the Faculty Credentials and Promotion Committee reviews, and the Dean or Commandant recommends an individual for initial appointment or promotion. The Academic Board exercises approval authority. Heads of departments forward nominations for promotion through the Dean or Commandant to the Faculty Credentials and Promotion Committee by 15 January to permit promotions and appointments to become effective by the start of the fall semester each year.

Faculty Salaries. Faculty salaries also influence retention. The system for determining salaries is very different for military and civilian faculty. Military pay is determined by military rank and not by location (although there is a small cost of living adjustment based on location). Therefore, pay does not influence retention of officers at the military academy. in the department, or in the program. Title 10 civilian faculty are unique to West Point, and so payment of competitive salaries is necessary for faculty retention. These systems are described below.

- *Military Pay.* Active duty military pay is governed by the Department of Defense common table of pay and allowances. Active duty military members receive a standard base pay determined by military rank and total years of military service. Members also receive a basic allowance for housing, the amount determined by the member's military rank and duty station zip code. In addition, special pay may be available depending on special qualifications (medical professionals, flight rated pilots, etc.).

- *Civilian Pay.* The Director of Civilian Personnel, Assistant Secretary of the Army (Manpower and Reserve Affairs) determines the salary schedule for Title 10 civilian faculty members, including faculty who are members of the Dean's Staff. This salary schedule is modified on a comparative basis with changes Congress authorizes for Federal employees paid under the Classification Act. The term *academic rank* on the schedule refers to the academic grade of an individual, and the term *step* refers to the salary level within the academic rank. The salary schedule is published separately each year.
  - *Salary Steps.* The Dean or Commandant determines the salary step for appointments of faculty. The *Oklahoma State University (OSU) Faculty Salary Survey* provides the standard against which USMA faculty salaries are compared. The 9-10 month salaries published in the OSU study are scaled appropriately for the 12 months of employment expected of USMA faculty. Such factors as the availability of funds, the academic discipline, and the faculty member's experience, education, and prior professional achievement provide the basis for initial step determination. A promotion in academic rank normally results in a salary adjustment equivalent to two steps above current salary if funding is available.
  - *Cost-of-Living Pay Increases.* The Title 10 faculty salary schedule may be modified on a comparative basis with changes authorized by the Congress for cost of living. Headquarters, Department of the Army makes pay adjustments to the Title 10 salary schedule on the same basis as those increases made to the General Schedule salary schedule. In January 2019, a 2.11%pay increase was authorized for all Title 10 and Title 5 employees.
  - *Merit Step Increases.* Every even calendar year, every Title 10 faculty member receives a step increase.
  - *Salary Adjustments.* Each year an extensive review of faculty salaries is conducted by the Office of the Dean. Based on these studies and available resources, selected faculty members may have their salaries adjusted upward to better reflect the contributions these individuals make to the department, the Academy, or to the discipline. Faculty members may at any time request a review of their salary through the Associate Dean for Plans and Resources.
  - *Faculty Benefits.* Job security, health care, and quality of family life benefits are shown below in Table 8-5.

E. Support of Faculty Professional Development

Professional development activities available to the faculty are discussed in Criterion 6, pages 6-8 to 6-11. These activities are listed below:

- Journal and book publications
- Professional conferences

- New instructor training
- Mentorship program
- Military and civilian professional rating systems
- Center for Faculty Excellence Master Teacher Program
- Department seminars

Many of these activities are financially supported by the institution or through individual faculty research grants. Support for faculty travel to conferences varies considerably on a case-by-case basis, and this is discussed below. Evidence for support is indicated by the degree of activity. For example, faculty professional development activities for the past five years are listed in Table 6-3 in Criterion 6. As discussed, the 10 department faculty members have an active record of travel to conferences. The program faculty produced 106 conference proceedings, or about 2 per faculty member per year. Considering that USMA is an undergraduate institution, these numbers are encouraging, and provide evidence that the faculty members are obtaining support for professional development activities.

Sabbaticals are discussed in Dean's Policy and Operating Memorandum 3-9 (DPOM 3-9). As mentioned earlier in this self-study, all of the DPOMs are available for faculty and staff on the *internal* web site at http://usma-portal/dean/Pages/DPOMs.aspx, and are available to the review team on request. As discussed in the DPOM, sabbaticals are encouraged to provide a period of intellectual renewal, disciplinary updating, and scholarly concentration to senior faculty. All eligible faculty members are permitted to request a two-semester sabbatical at full pay once six years of continuous service has been rendered. Backfill of faculty positions is subject to the availability of funds, so faculty members are encouraged to seek external funds to help offset this cost, but this is not required. A faculty member may take two nonconsecutive semesters for sabbatical. Sabbatical with pay carries with it an expectation for continued service at USMA for one year. Sabbaticals may be temporarily suspended during periods of financial exigency. Sabbaticals may be combined with summer periods to make the sabbatical appear to be one year in length. All sabbatical proposals require coordination with and approval of the Department Head and the Dean.

Travel for professional development, such as conferences, seminars, and workshops is planned by the faculty member in coordination the department. Faculty travel is known as "temporary duty" or TDY. TDY travel orders are entered into the Defense Travel System (DTS). DTS orders are approved by the Department Head after careful review by the faculty member's course director, supervisor, Administrative Officer, and Department Executive Officer. All faculty members are required to complete a TDY worksheet, which requires signatures of each of these people to be approved. Faculty travel can also be supported through Department Gift Funds, which is about $48,000 for the program. These funds are available for faculty if the faculty travel is necessary to support cadet activities, such as student attendance and presentation at national conferences.

Table 8-5. Job security, health care, quality of family life and professional development benefits for faculty and staff.

	Professor, USMA	Academy Professor	Rotating Military	USMA Title 10 Civilian	USMA Title 5 Civilian	Benchmark Schools	Civilian Staff
Job Security Benefits							
Tenure[1]	●	●		●		●	●
Mandatory Retirement[2]	●	●	●				
Due Process at Termination	●	●		●		●	●
Advance Notice of Termination[3]				●		●	●
Can Resign without Notice[4]				●			●
Early Retirement[5]	●	●	●	●			●
Health Care at Retirement[6]	●	●	●				●
Guaranteed Pension[5]	●	●	●	●			●
Thrift Savings Plan[7]	●	●	●	●			●
12-Month Employment	●	●	●	●			●
Health Care Benefits							
Medical Care Self[12]	●	●	●	●	●	●	●
Medical Care Family[12]	●	●	●	●	●		●
Dental Care Self[12]	●	●	●	●	●	●	●
Dental Care Family[12]	●	●	●	●	●		●
Vision Care Self	●	●	●	●	●		
Vision Care Family	●	●	●	●	●		
Quality of Family Life Benefits							
Housing Assistance[8]	●	●	●				
Approval Needed to Live Off-Post	●	●	●				
Family Use of Recreational & Youth Facilities	●	●	●	●		●	●
Cadet Store Available	●	●	●	●			●
PX Available	●	●	●				
Commissary Available	●	●	●				
Training Holidays	●	●	●				
16-Week Semester	●	●	●	●			
Annual Leave[9]	●	●	●	●			●
Sick Leave[14]							
Professional Development Benefits							
Department Head / Deputy Head Opportunity	●					●	
Deputy Head Responsibilities	●	●		●		●	
Academic Leadership	●	●	●	●		●	

Education Funding Self[13]	●	●	●				●
Educational Funding for Family						●	
Admissions Preferences for Children						●	
Sabbatical[10,11]	●	●		●		●	
Sabbatical at 1 Year Full Pay	●	●		●			
Sabbatical Replacement Provided	●	●				●	

Notes

1. Professors USMA have a 5-year review and Academy Professors have mandatory retirement at 28/30 years. Civilian Title 5 staff members go from “career conditional” to “career” status after 3 years. Tenure (i.e., conversion to Permanent appointment) is available to faculty members who attain Associate Professor or Full Professor status, effective date conditional on availability of a tenured slot
2. Mandatory retirement age is 64 for PUSMA, LTC 28 years, and COL 30 years of service.
3. Civilian Title 10 faculty may not receive advance notice of separation if due to an egregious offense, or other factors outside USMA control. Civilian staff are given 120 days of advance notice.
4. Academy and rotating military faculty incur Active Duty Service Obligation (ADSO) as a result of attending a fully-funded graduate program. Advanced notice for termination of Title 5 employees is 120 days.
5. Military faculty are vested at 20 years; civilian faculty and staff in the FERS system can retire at age 55 after 20 years but will incur a penalty until age 62. A pension is guaranteed in the FERS system after 5 years of service.
6. A program for civilian faculty and staff is offered but must be paid for by the retiree.
7. Annual contribution up to $17,500 limited by IRS. Civilians receive up to 5% matching.
8. Government housing (or housing allowance) for military is required by law. Housing assistance is provided to civilian coaches and visiting professors.
9. Military annual leave is 30 days, and they are charged leave for weekends and holidays. Civilians receive 13-26 days paid vacation and are not charged for weekends and federal holidays.
10. Civilian and military sabbatical with pay carries with it an expectation for continued service at USMA for 1 year.
11. Data for benchmark schools is from the “Hanover Research Report - Peer Sabbatical Leave Programs – United States Military Academy” published March 2013.
12. Medical and dental is available but must be purchased.
13. Program availability depends on funding. Staff can be reimbursed for college courses and book expenses if the course is job-related and they receive a grade of C or higher.
14. Civilians (T5 and T10) accrue 4 hours of sick leave per pay period for the duration of the employment.

PROGRAM CRITERIA (FOR CHEMICAL, BIOCHEMICAL, BIOMOLECULAR, AND SIMILARLY NAMED ENGINEERING PROGRAMS)

Describe how the program satisfies any applicable program criteria. If already covered elsewhere in the self-study report, provide appropriate references.

From the 2020-2021 Criteria for Accrediting Programs:

Curriculum

The curriculum must include:

a) Applications of mathematics, including differential equations and statistics to engineering problems.

b) College-level chemistry and physics courses, with some at an advanced level, as appropriate to the objectives of the program.

c) Engineering application of these sciences to the design, analysis, and control of processes, including the hazards associated with these processes.

The Chemical Engineering Program satisfies the specific Program Criteria for programs designated as chemical engineering. This criterion includes aapplications of mathematics, including differential equations and statistics to engineering problems. The criterion also requires college-level chemistry and physics, with some at an advanced level, appropriate to the objectives of the program. Finally, the criterion requires that the program include application of these sciences to the design, analysis, and control chemical processes, including analysis of hazards associated with chemical processes. To support the program criterion, our program contains courses in the categories of physical sciences, chemical sciences, mathematics, general engineering and advanced engineering electives, as well as courses in design, analysis, and control of chemical processes.

To illustrate support of the program criteria to the required curricular content areas, the courses comprising the chemical engineering program were analyzed in terms of the credit hours in each category, as a percentage of total credit hours in the program, for all courses containing either engineering topics or mathematics, statistics, and basic science credit in Table 5-1 (94.5 credit hours total). The credit hours were binned into each of the five categories, and the results are shown as percentages in Figure PC-1. The chemistry basic science component is achieved through courses in general and organic chemistry, which together comprise 12.2% of the program. Additional basic science coverage occurs in the general physics and physical geography courses, which together comprise 11.2% of the program total. Mathematics, statistics, and engineering mathematics comprise 20.5% of the program. General engineering comprises 18.6% of the program, but about half of this occurs in advanced engineering electives. This is intended to allow students a degree of specialization as they customize their own individual curricula. Since individual student curricula vary from student to student, the average effect is to produce a generalization of the skills of the collective population, which is why we counted these as general engineering credits.

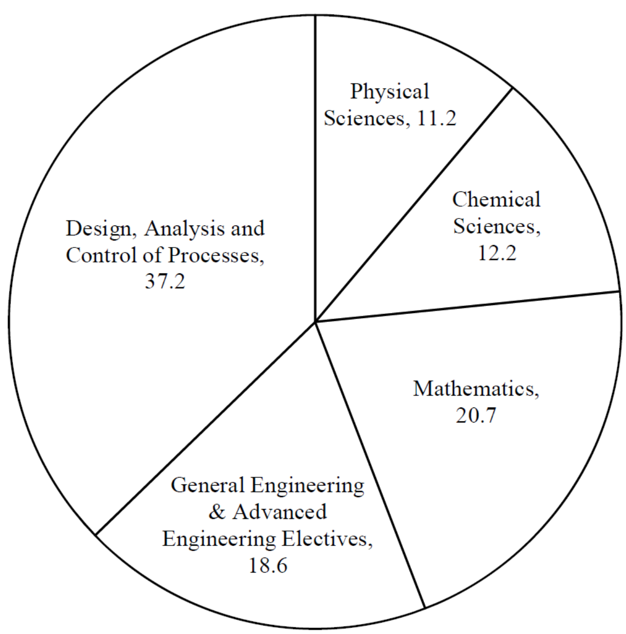


Figure PC- 1. Percentage of the 95.5 program credit hours supporting coverage of Program Criteria content areas.

The structure of the chemical engineering curriculum was discussed in Criterion 5, pages 5-16 to 5-20. As shown in Table 5-7, the program curriculum is aligned with the content areas of the FE chemical engineering discipline-specific exam. Also, as discussed in Criterion 5, the FE exam content thoroughly covers essential chemical engineering topics, and passage of the exam is required for licensure in all 50 states. Since the curriculum aligns closely with these topics, we feel that we are adequately representing the needs of our professional constituency. As pointed out in Criterion 2 (pages 2-12 to 2-21), a careful examination of job postings for government and Army chemical engineering positions shows that they universally emphasize the importance of the FE exam. Thus, we are confident that we are also meeting the needs of the Army constituency as reflected in this broad survey of its published job postings. Overall, we are satisfied that the content of the curriculum satisfies the needs of the program constituencies.

The chemical engineering program at USMA has done an extensive survey of civilian colleges and universities to determine the areas emphasized in contemporary chemical engineering programs. That study is discussed in Criterion 5 and summarized in Table 5-8. Based on this extensive effort, we feel we are in very good agreement with the national averages in each topical area. There are some minor differences between our program and the national averages, but our credit hour coverage is in very good overall alignment. We also acknowledge that chemical engineering as a field is diverse. As a result, chemical engineering departments offer many different types of programs. A significant number of departments offer multiple majors in chemical, biomolecular or biochemical engineering. We analyzed those programs that were identified as "chemical engineering." We also point out that Table 5-8 does not show the number of credit hours of life science courses. That average is 1.9 credit hours per chemical engineering program, with 84 out of 159 programs having no life science requirement at all.

Figures PC-2 through PC-4 show the sequence of courses leading to coverage in the specific areas designated in the Program Criteria. Core courses are shown in white, and upper electives are shown in green. Prerequisites are indicated with solid arrows. Course descriptions are provided in Appendix A. It is important to point out that these sequences are not static and have undergone some changes over the last six years. However, these figures represent a snapshot of the program in its current configuration.

By the time our students are in their senior design course, they will have completed all of the basic science and mathematics requirements. Referring to Figure PC-2, the sequence begins in the freshman year with two semesters of General Chemistry (CH101 and CH102) and two semesters of calculus (MA103 and MA104). General Physics (PH205 and PH206) is normally taken in the sophomore year, and the sophomores also study advanced calculus (MA205). Probability and Statistics (MA206) is also normally taken sophomore year at USMA, but chemical engineers move this forward to junior year and take Engineering Mathematics (MA364) in the sophomore year, prior to the majority of their chemical engineering courses. Junior year, the students study Organic Chemistry (CH383), and many cadets take this course sophomore year. Critically, Organic Chemistry is taken by all students prior to Chemical Reaction Engineering (CH364).

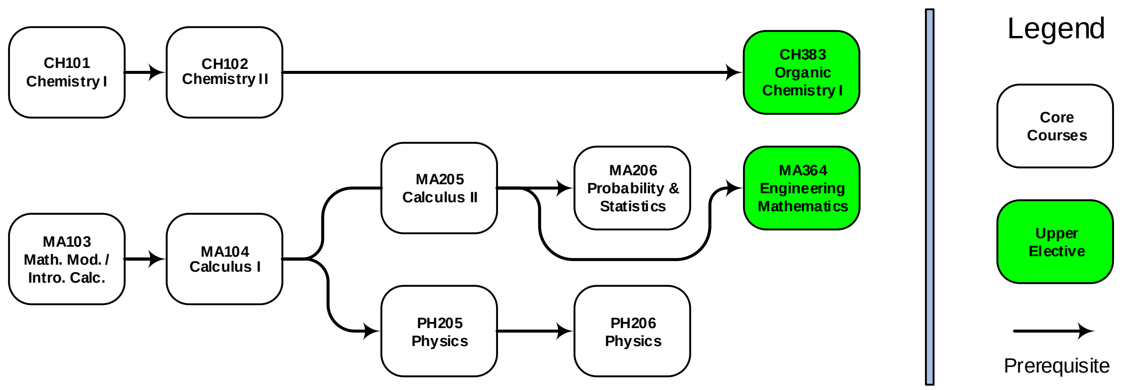


Figure PC- 2. Sequence of mathematics, chemistry and physics courses in the USMA chemical engineering program.

The curriculum provides a thorough grounding in mathematics, including applications of differential equations, multivariable calculus, statistics, and linear algebra to engineering problems. This is accomplished primarily through the core math sequence that includes Mathematical Modeling and Introduction to Calculus (MA103), Calculus 1 (MA104), Calculus 2 (MA205), and probability and statistics (MA206). The math modeling course also introduces numerical methods for solution of differential equations, with many problems involving practical applications. Multivariate calculus and linear algebra are covered in Engineering Mathematics (MA364), which also contains a considerable engineering context. Significant applications of multivariable calculus occur in Chemical Engineering Thermodynamics (CH365) and applications of differential equations in Chemical Reaction Engineering, Automatic Process Control and Heat and Mass Transfer (CH364, CH367 and CH485). Students also encounter coupled differential equations in the Heat and Mass Transfer and Chemical Reaction Engineering courses.

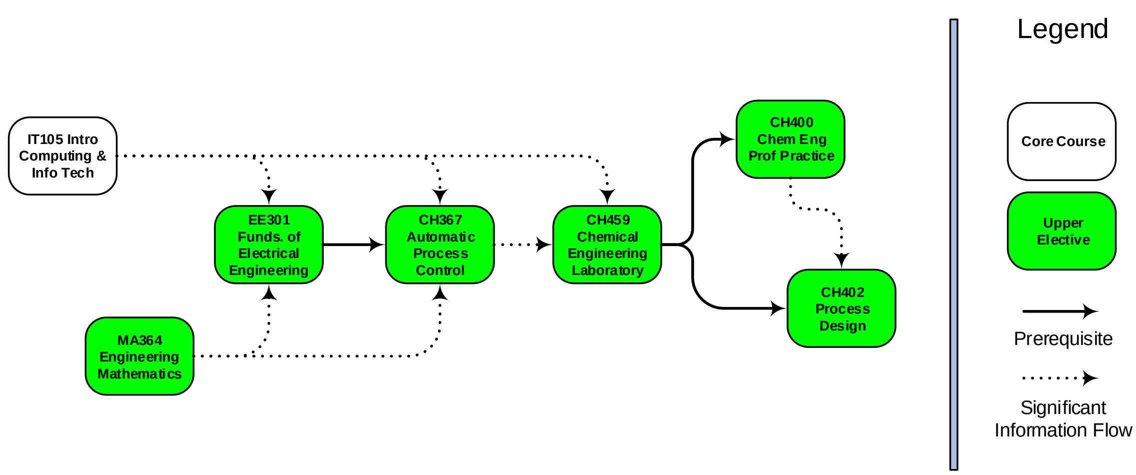


Figure PC-3. Process control sequence in the USMA chemical engineering program.

The courses contributing to process control requirement are shown in Figure PC-3. The sequence begins in the freshman year with IT105 Introduction to Computing and Information Technology. This course introduces the principles underlying the use, function, and operation of digital computers and information technology. The students are exposed to microcontrollers, sensors, and data acquisition, as well as programming of microcontrollers. The students are also taught basics of networking and networking hardware, which is useful for understanding networking of programmable logic controllers in modern process control systems. The next course in the sequence is MA364 Engineering Mathematics, where students learn tools necessary for analysis of control systems, such as Laplace transforms and time-varying differential equations. The course EE301 Fundamentals of Electrical Engineering continues the students' exposure to information technology and linear circuit design. In CH367 Automatic Process Control, students learn Laplace-Transform methods for designing, modeling, and analyzing control loops. This is a traditional course in process control and covers physical models of controllers and systems, both in the time domain and in the Laplace domain, as well as how to develop Laplace block diagrams. Process control applications are covered heavily in the Unit Operations Lab, CH459, where students are exposed to automatic and manual control loops on every major piece of equipment. Students are asked to differentiate between open and closed control loops, understand feedback control, and sketch control loop diagrams using Laplace block diagrams and piping and instrument diagrams (P&IDs). CH400 Chemical Engineering Professional Practice uses simulators to teach plant dynamics, and covers startup, running at steady state, shut down, and how to respond to process upsets. Finally, in CH402 Chemical Engineering Process Design, students must apply the concepts learned in the earlier courses. They learn to integrate elements of safe process control into the final process design, including identification of key control points and relief devices, and they are required to produce full P&IDs of the process.

The engineering design and analysis sequence is shown in Figure PC-4. The sequence begins in CH362 which is the Mass and Energy Balances course, covering basic flow charts and single and multiple unit mass and energy balances. CH363 covers design and analysis of equilibrium staged separation processes, including Raoult's Law processes (such as flash and distillation), Henry's Law (absorption and stripping), and distribution coefficient (liquid-liquid extraction) methods. Diffusion based methods for calculation of stage efficiencies and packed column sizes are also covered. CH364 Chemical Reaction Engineering covers reaction kinetics, introductory chemical reactor design, and mass transfer and reaction in solid catalysts. The CH459 Unit Operations Lab integrates concepts from the earlier courses into pilot plant theory and operation, safety, automatic process control, and process modeling. The modeling portion of the course is conducted in CHEMCAD, which is structured to require comparison of simulated and experimental results, giving the students a deeper appreciation of their experimental measurements and preparing them for further, more advanced use of the software in the senior design course. A significant feature of our program is that process modeling is integrated throughout the CH362/363/364/459/402 sequence of courses, so that the students are acclimated, comfortable and competent with the use of CHEMCAD by the final semester. The courses MC311, MC312, and CH485 form our sequence in transport phenomena. These courses cover basic fluid thermodynamics, macroscopic and microscopic momentum transport, and mass and energy transport theory.

The engineering design and analysis sequence culminates in CH402 Chemical Engineering Process Design. The major design experience is discussed in Criterion 5, pages 5-19 to 5-20. The course covers equipment and process design and economics. The students are first exposed to a series of "small" design topics and projects, such as piping, pumps, heat exchanger design, and analysis of working plants. In some of these projects, the students learn how to perform detailed physical design of the individual process units. The students are then exposed to engineering economics and decision theory, including how to annuitize capital costs for comparison with cash flows from react and product streams. The last portion of the course, approximately 50% of the course, is devoted to a comprehensive design project in which the cadets are exposed to real-life scenarios where they need to design a process to meet specific needs.

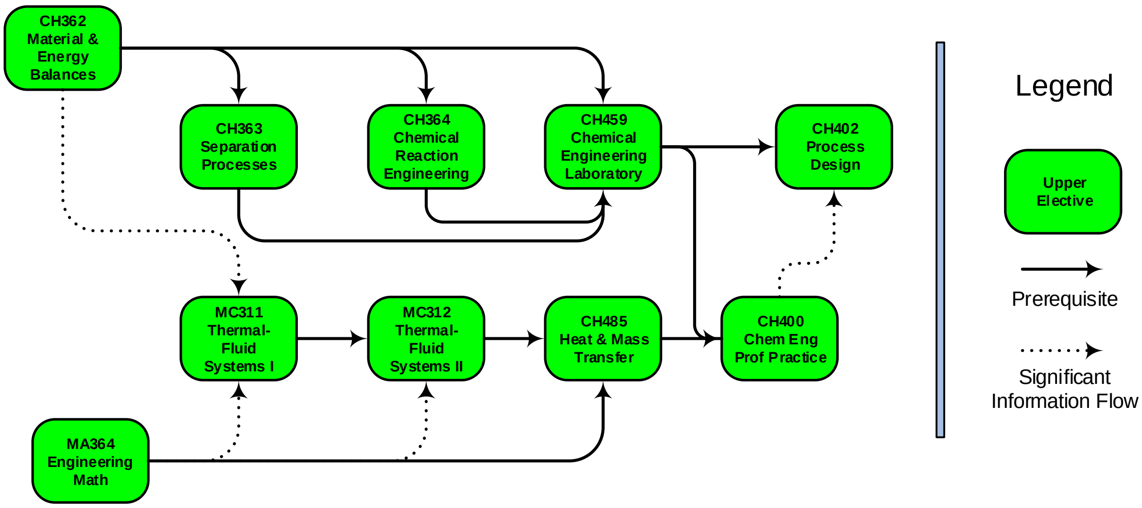


Figure PC-4. Engineering design and analysis sequence in the USMA chemical engineering program.

Upcoming Curricular Changes

At the inception of this program, focus was placed on the type of process engineering that would most likely be employed in regions in which graduates were likely to find themselves, most notably, the Middle East and Afghanistan, where traditional chemical engineering processes are still largely employed. The reality is that students employed as lieutenants in the Army need the broadest exposure possible, and so some emphasis was placed also on breadth across the engineering practice. The alignment of the program, therefore, was focused on traditional chemical process engineering. Given the growing emphasis within the US Army for stability operations within these theatres of operation, this will most likely continue to be of prime importance. Among many disciplines with ties to traditional chemical engineering, the chemical engineering program recognizes the rapid growth of the field of bioprocess engineering, particularly in the United States, Western Europe, and Japan. In these regions, bioprocess engineering already has a considerable history in such areas as agrochemical processes, food and beverage processes, wood and paper processes, and pharmaceuticals. Within these processes, traditional chemical engineering principles continue to be employed, and bioprocess engineering is being developed and employed at a rapid pace as companies continue the trend toward increased economic efficiency. Bioprocess engineering is not as mature in the developing world, particularly in regions in which our graduates are most likely to be assigned.

However, we recognize that the civilian chemical engineering profession is also a major constituency of our program, especially since approximately 50% of our graduates enter the civilian work force after five years of service in the Army. One of the reasons why we did not introduce courses in areas such as bioengineering, biochemical engineering, or industrial microbiology is that the core curriculum included 26 courses and did not allow time in the schedule for the students to take the prerequisite basic life science courses, meet the ABET minimum in the engineering sciences, and still graduate in 47 months. USMA recently revised the core curriculum, adding a general biology course, reducing the number of core courses by two, and ABET recently reduced the number of required credit hours in basic and engineering sciences in the 2019-2020 review cycle. These developments should allow our program a considerable amount of flexibility in designing courses that use the life sciences as a background. We are currently discussing future configurations of the program that would incorporate additional bioprocess engineering. One result has been the introduction of a new course in bioengineering modeling and analysis (CH450) in AY2019 that includes significant coverage of topics in bioprocess engineering. We are currently planning on hiring an additional civilian faculty member and an additional academy professor in bioengineering and we continue to seek input from our constituencies for further changes. We emphasize that revisions to the program will be made through existing continuous improvement processes without sacrificing skills that might be of more general use to Army officers or which might degrade performance in the assessment of our outcomes.

Hazards Associated with Chemical Processes

The program addresses the hazards associated with chemical processes in several ways, and safety education is integrated throughout our curriculum. Safety education starts in the general chemistry courses and continues in organic chemistry with basic lab safety and hygiene. Students are taught to use basic chemical protective gear such as safety goggles and aprons, which they must where in the lab at all times without exception. Organic chemistry includes discussions of safety hazards and has included a green chemistry project (lab 6). Beyond this, the program is engaged in the following exercises and activities:

- *Safety and Chemical Engineering Education (SAChE).* As described on the SAChE website, 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 and graduate students studying chemical and biochemical products and processes. The SAChE committee comprises academics, industrial practitioners, and AIChE staff. The SAChE committee has developed and published a series of recommendations for ABET on how chemical engineering programs can meet the ABET curricular requirements and has also developed and published an educational program to meet the ABET recommendations.
    - SAChE Website:
      http://www.sache.org/
    - Center for Chemical Process Safety (CCPS) website:

https://www.aiche.org/ccps

- Series of recommendations for ABET: http://www.sache.org/SACHEGuidelinesForABET.pdf
- SAChE Student Safety Certificate Program website: http://sache.org/student_certificate_program.asp

SAChE awards certificates for completion of each element of the Student Safety Certificate Program. Our students complete certificates in:

(1) Basics of Laboratory Safety
(2) Understanding Hazards and Risks
(3) Nitrogen's Role in Safety,
(4) Process Safety Lessons Taught from Experience,
(5) Dust explosion control,
(6) Inherently Safer Design,
(7) Safety in the Chemical Process Industries,
(8) Risk Assessment,
(9) Runaway Reactions, and
(10) Chemical Reactivity Hazards.

Our students have completed and have received these certificates since 2012. We believe this means that they therefore satisfy the SAChE recommendations for ABET safety content in Chemical Engineering. Since AIChE is responsible for SAChE as well as for the ABET Program Criteria, we are in compliance with the safety portion of the Program Criteria. The SAChE program continues to grow and add certificate courses, and we are in the process of revising our SAChE requirements to keep it current.

Our students are required to complete all ten of the available SAChE certificates in the SAChE Student Safety Certificate Program. Since inception of the program in AY2013, we have had 100% of our students achieving all ten certificates. This can be readily confirmed since SAChE maintains a record of certificate holders. We require our students to present pdf copies of their certificates pass CH459. We also confirm their records through the SAChE customer support at customerservice@aiche.org. Our most recent contact at AIChE is Christa Pennino (chrip@aiche.org) who sent us the records confirming the certificates of our students.

- *Risk assessment review in CH459.* The risk assessment worksheets (DD Form 2977) discussed in Criterion 7 on page 7-17 are prepared by instructors with at least one review by a senior instructor. The risk assessment form follows a general HAZOP format, identifying the hazards, risk level, controls, residual risk level associated with each subtask, how the controls are implemented, and who is responsible for administering the controls. The risk assessments are reviewed and signed by the students prior to conducting experiments.

- *Plant training using simulators.* Our program uses 3-D immersive simulators to introduce students to distributed control systems, safe process startup and shutdown procedures, and response procedures for process upsets. The simulator training begins in the CH459 course, where students are introduced to the distillation process. Simulator training continues in the second half of CH400, where students continue with the distillation process and learn about more advanced processes such as fluid catalytic cracking. Simulator training also includes controller tuning exercises in CH367. In CH400, the student simulations are graded electronically against criteria pre-programmed by the instructor, such as time in an alarm state before a response is taken. Scores are reviewed by the students, who can attempt exercises multiple times in an effort to improve their scores. The simulators also feature inside and outside plant views, so the students can role-play as inside or outside operators engaged in various training scenarios. Students also learn about the location and operation of all inside and outside instrumentation and controls so that they can pre-plan their response plans.
- *Environmental Impact, Process Safety and Human Exposure Risk Analysis in the Senior Design Project.* The senior design project has a requirement to include a process safety, exposure, and environmental analysis. The guidance to the students is that their design must not pose any environmental, health or safety hazards that should have been mitigated with better equipment, instrumentation or control. They explore safety and environmental analysis from CHEMCAD using 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, if present. Specifically, the course uses a rubric to assess various levels of performance in each of the three categories, and an aggregate score is forwarded for program-level assessment. For example, students in AY2019 have an overall score of 78.8% based on individual scores of 55.4%, 91.7%, and 89.2% in environmental impact, process safety and human exposure risk analyses, respectively. (The low score in environmental was due to two groups doing a relatively poor job on the final report, but their actual research was significantly better, as reflected in IPR scores.)
- *New in AY14 – Safety in Design Checklist.* The checklist is based on a two-page document that appears at the front of all process designs at a major oil refining company. Our version of the checklist asks the students to review their design from the point of view of equipment layout, existing facilities, pressure and temperature contingencies, safety facilities, instrumentation, pressure relief, utilities and other special items such as fireproofing, effects of flashing, brittle fractures, and so on. The checklist is very detailed in its present form and has been customized for use in the senior design course (CH402), but still retains the details found in the industrial version.
- *New in AY15 – Unit Supervisor's Pre-startup Safety Review.* This exercise uses an audit sheet that requires the students to answer a series of questions about the unit and the surrounding facilities before they are permitted to begin startup operations. Students go through a detailed inspection and address questions about the instrumentation and electrical systems, piping and valves, insulation, signage and

identification, relief devices, firefighting equipment, platforms and ladders, sewers and drainage, and procedures and training. The sheets were developed from similar audit sheets provided by a major oil refinery company and have been in use since AY2015.

- *Advisory Board Expertise and Review.* Two of our advisory board members have extensive experience in plant and process safety. Don Glaser, owner of Simulation Solutions, Inc., has extensive knowledge of plant simulations and operator training, and has designed and developed custom process simulators for companies around the world. He has produced and taught numerous industrial training courses on process safety operations. Don co-authored a paper with us (see "Using Simulators to Teach Process Safety," AIChE Annual Meeting Conference Proceedings, Nashville, TN, Nov. 8-13, 2009) outlining our program's philosophy on the use of process simulators to create an inherently safer and more realistic design experience. A second board member, Paul Dietrich, now retired, has 35 years of plant engineering experience, most recently at the Bayway Refinery in Linden, NJ, where he was involved in all aspects of plant operations. Paul was specifically recruited by our program because of his extensive knowledge of plant engineering. Paul has been helping us to incorporate the Safety in Design Checklist into our senior design course (CH402) and the Unit Supervisor's Pre-startup Safety Review into our unit operations lab (CH459).
- *Performance on the Fundamentals of Engineering (FE) Exam.* The FE exam contains an average of 5 questions on process safety per exam. 100% of our students take the exam, and we receive an institutional report with a topical breakdown of our students' performance. The sample size is significant. With 24 students and 5 questions per student, the institutional average contains on average 120 separate data points. We typically do quite well on this topic. For example, in 2018, the institutional report shows that our students scored 10.5 out of 15.0 against a national average of 9.8, which is considered to be an excellent score.

In summary, we feel our program strongly complies with the program criteria requirement that the curriculum cover hazards associated with chemical processes. Our students participate in and complete all available certificates in the SAChE program. There is a strong safety culture in the department that is engaged in a well-developed risk assessment process. Safety activities are integrated throughout the curriculum in various activities in the courses. We have strong advisory board interest and participation in these activities. We have embedded process safety into our student outcomes and the performance of the students in process safety is assessed on an annual basis. Finally, implementation and assessment of these efforts has been stable and continuous over the last nine years. Taken together, this is a very strong and comprehensive effort.

ACCREDITATION POLICIES AND PROCEDURES MANUAL

[Pages APPM-1 to APPM-5] Describe how instructional and learning environments used by the program (including facilities, tools, and equipment) are safe for their intended purposes. (See the 2020-2021 APPM section I.E.5.b. (1).) Examples of information may include efforts to keep laboratories clean and free of hazards, student training, personal protective equipment used by students, safety policies and procedures, enforcement of safety policies, and routine safety inspections. [Quoted from the Self Study Questionnaire]

This section contains a description of the program's compliance with ABET guidance as specified in the Accreditation Policies and Procedures Manual, (2020-2021 APPM section I.E.5.b. (1)).

[Red font page numbers added by USMA Chemical Engineering]

Maintaining a safe learning and instructional environment is of prime importance to the program and the department. The program complies with all safety procedures and policies of the department. The department maintains all of its safety policies in documents posted on the department SharePoint site. The site is available only internally, is found at: https://usarmywestpoint.sharepoint.com/sites/cls. Once at the site, the documents are found by clicking on the “Safety” tab on the upper right side of the page. There are re are eight directories in this site that contain the information most relevant to the chemical engineering self-study:

- Policies and Procedures, which includes the department’s *Laboratory Safety Policy Memo*.
- Laboratory SOPs (Standard Operating Procedures), which includes the department’s *Chemical Hygiene Plan*
- Forms and Checklists, including the
  - *Composite Risk Management Worksheet DD Form 2977*
  - *U.S. Army Accident Report Form DA285-AB*
- HSI Safety Training Link
- Training Records

These files are available to the ABET team upon request. They explain the safety policy for the department. All faculty and lab staff in chemical engineering and in the department are required to know and understand the contents of these documents.

Laboratory Safety Policy Memo. The Laboratory Safety Policy Memo outlines the department’s strategy to control hazards based on prioritized levels of intervention, including engineering controls, administrative controls, work practices, and use of personal protective equipment. The memo also describes the department’s Laboratory Safety Program, which includes hazard identification, chemical hygiene plan, information and training, exposure monitoring and medical consultations and exams. Finally, the memo describes the roles and responsibilities of the various department personnel responsible for implementing the department’s safety policy, to include the department head, the Chief Hygiene Officer (Lab Program Director), and the Safety Committee (Deputy Department Head), lab supervisors, and lab workers, including cadets.

Composite Risk Management Worksheet DD Form 2977. All lab exercises and demos in the department must have a composite risk management worksheet completed by the person who is responsible for running the experiment, exercise or demo. This form identifies the hazards, risk level, controls, residual risk level associated with each subtask, how the controls are implemented, and who is responsible for administering the controls. The form is reviewed and discussed by at least two individuals. In chemical engineering, these would be the course director, the lab technician, and the program director. The purpose of this discussion is to ensure that there is a formalized effort to review the identified hazards and to see if there is anything that was overlooked. The forms are reviewed annually, and hard copies are maintained in the chemical engineering laboratory.

Chemical Hygiene Plan (CHP). This document is a detailed description of the department’s implementation of specific requirements the U.S. Occupational Safety and Health Act of 1970, the U.S. Department of Labor (including 29 CFR 1910.1450

Occupational Exposure to Hazardous Chemicals in Laboratories), the Department of Defense and Department of the Army (a complete list is on page 4 of the CHP). The CHP is a written program developed and implemented by the Department which sets forth procedures, equipment, personal protective equipment and work practices that are intended to protect all occupants of Bartlett Hall from the health hazards presented by hazardous chemicals and biological agents used within the Department. It also lists the duties and responsibilities of key safety personnel in the department, including:

- Department Head
- Course Directors, instructors, and researchers
- Chemical Hygiene Officer
- Lab supervisors
- Lab workers
- Cadets

The purpose of the CHP is to describe the proper use and handling practices and procedures to be followed by employees, cadets, visitors, and other personnel working in each laboratory of the Department of Chemistry and Life Science to minimize exposure to hazardous chemicals in the laboratory and to set forth guidelines for personnel (faculty, staff, cadets, visitors, etc.) engaged in the use of hazardous chemicals. The CHP is the foundation of the Department laboratory safety program and is reviewed and updated, as needed, on an annual basis to reflect changes in policies and personnel. The CHP also assists in promoting a culture of safety to protect all personnel while working in laboratories.

As articulated in the CHP, the department philosophy is that while the safety documents describe work practices to promote safety in the laboratory, each individual has the ultimate responsibility for ensuring that good practices are implemented. Not only does this individual responsibility promote personal well-being and the well-being of others, it also advances USMA's commitment to excellence in teaching and research. The documents outlined above are intended to inculcate this philosophy in all department personnel, as well as to develop a safety-conscious culture within the department. Along those lines, this culture is further re-enforced with department training and safety inspections. Department-wide training occurs annually and takes the form of a one-hour safety seminar conducted by the department head and the head of the safety committee. In addition, research group specific training, tailored to the needs and specific hazards of each project, occurs through an on-line service called Health and Safety Institute (HSI). Prior to conducting research, members of each group must complete the required on-line training. The following inspections are all done periodically:

- The Safety Committee does quarterly inspections.
- The Academy does an annual building inspection. This is conducted outside of our department; it is a building, not just a department inspection.
- The Army conducts a post-wide facilities inspection every three years.

Accident Report Form DA285-AB. These forms are required for all safety incidents in the department. They give all of the details of the person involved and the accident or incident that occurred. Once the report is completed, it is submitted to the USMA Safety

Director. The incident is thoroughly investigated, and corrective actions taken. Examples of incidents from the last ten years include:

- Cadet had pipette break during an experiment, with glass being forced into her hand, August 24, 2011. Corrective Action: Pre-lab briefing was changed to increase the emphasis on hazards of glassware breakage.
- Cadet squeezed a cup containing chemicals, causing chemicals to squirt into his face September 19, 2011. Corrective Action: Performance of demo was suspended, and demo was redesigned to prevent a recurrence of the incident.
- Office Admin staff member tripped and fell down a flight of five stairs, injuring her wrist, September 26, 2011. Corrective Action: Non taken; no tripping hazard was found after investigation. The individual involved was given medical attention.
- While using a concentrated acid, a small amount was splashed onto the wrist of a cadet that resulted in minor burns, February 26, 2014. Corrective Action: Longer chemical resistant gloves were procured and used when concentrated acids/bases are required. The correct selection of and use of PPE when using concentrated acids/bases is now emphasized in safety briefs.

We included these descriptions in the self-study to emphasize that the program has a system in place for correcting safety issues, and that the system appears to be working. We also would like to point out that while these incidents took place in the department, the chemical engineering program has not had any incidents over the last ten years of operation.

HSI Safety Training. In AY2019-2020, the department initiated a new safety training program from the Health and Safety Institute (HSI), https://www.hsi.com/. This online safety training program contains required reading assignments and instructional videos and examinations in in various safety topics. An example of the required training modules for one representative faculty member includes:

- Chemical Safety
- Fume Hood Safety
- Personal Protective Equipment
- Sharps Safety
- University Laboratory Safety – Analyzing Hazards
- University Laboratory Safety – Working Safely

Additional topics may be required depending on the specific topic or research lab in which a student, faculty, or staff member is working. Figure APPM-1 below shows a screenshot of a transcript for one faculty member, showing the enrollment type (requirement), completion status and time spent on the modules.

Training Records. This directory contains training briefs delivered to the department and records of IHS training requirements and status of all students, faculty and staff members in the department. The records are in the form of spreadsheets containing by-name lists of personnel indicating whether or not they have completed their requirements.

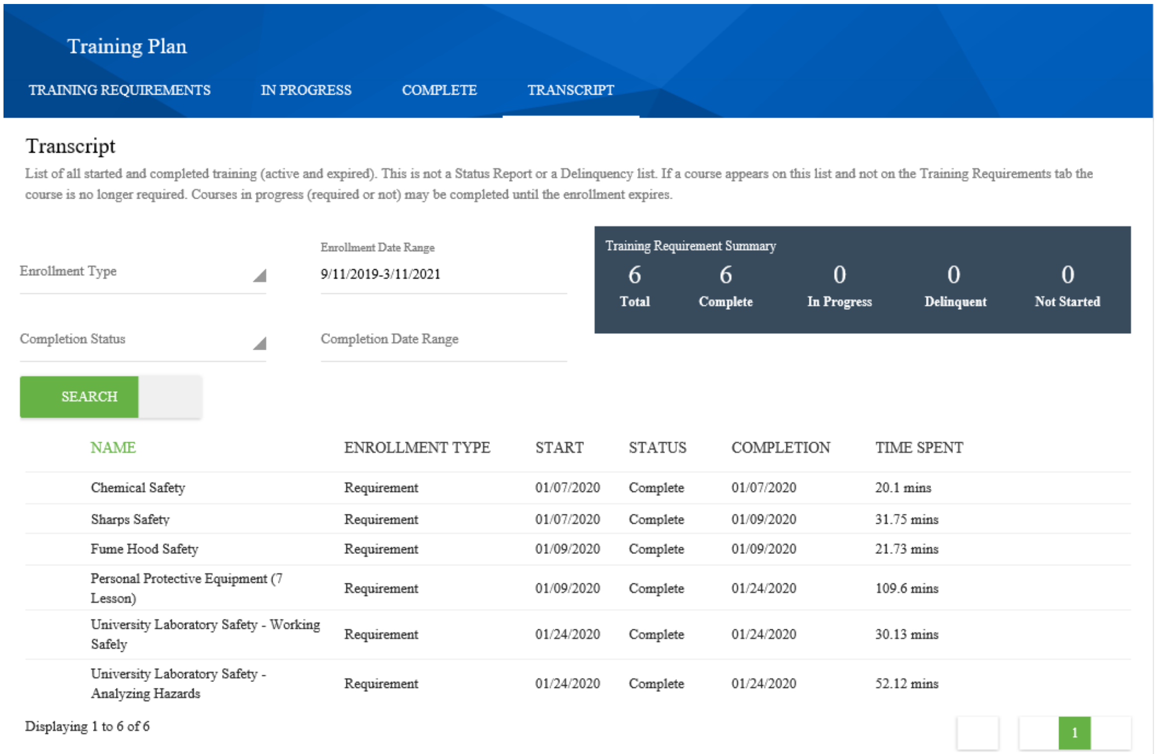


Figure APPM-1. IHS training transcript of a typical faculty member in the Department of Chemistry and Life Science.

Appendix A – Course Syllabi

Courses in the Chemical Engineering Program

Required Courses	Page
MA364 Engineering Mathematics	A-3
MA365 Advanced Math for Engineers and Scientists*	A-5
CH362 Mass and Energy Balances	A-7
CH363 Separation Processes	A-9
CH383 Organic Chemistry I	A-11
EE301 Fundamentals of Electrical Engineering	A-13
MC311 Thermal-Fluid Systems I	A-15
CH364 Chemical Reaction Engineering	A-17
CH367 Introduction to Automatic Process Control	A-19
MC300 Fundamentals of Engineering Mechanics and Design	A-21
MC312 Thermal-Fluid Systems II	A-23
CH365 Chemical Engineering Thermodynamics	A-25
CH459 Chemical Engineering Laboratory	A-27
CH485 Heat and Mass Transfer	A-29
CH400 Chemical Engineering Professional Practice	A-31
CH402 Chemical Engineering Process Design	A-33

**Chemical Engineering students are required to take either MA364 or MA365; MA365 is taken only by students who are in the advanced math track*

Pre-Approved Engineering Electives	
EE360 Digital Logic with Embedded Systems	A-35
EE377 Electric Power Engineering	A-37
EM411 Project Management	A-39
EM420 Production Operations Management	A-41
EM481 Systems Simulation	A-43
MC306 Dynamics	A-45
MC364 Mechanics of Materials	A-47
MC380 Engineering materials	A-49
ME472 Energy Conversion Systems	A-51
ME480 Heat Transfer	A-53
ME491 Mechanical Power Plants	A-55
NE300 Fundamentals of Nuclear Engineering	A-57
NE350 Radiological Engineering Design	A-59
NE450 Nuclear Weapons Effects	A-61
SE301 Found. of Engineering Design & Systems Management	A-63
SM484 Systems Dynamic Simulation	A-65
XE475 Mechatronics	A-67

Core Courses Containing Math, Basic Science, or Engineering Content	
CH101 General Chemistry I	A-69
CH102 General Chemistry II	A-71
CH151 Advanced General Chemistry I	A-73

PH205 Physics I	A-75
PH255 Advanced Physics I	A-77
PH206 Physics II	A-79
PH256 Advanced Physics II	A-81
MA103 Mathematical Modeling and Introduction to Calculus	A-83
MA153 Advanced Multivariable Calculus	A-85
MA104 Calculus I	A-87
MA205 Calculus II	A-89
MA255 Mathematical Modeling & Intro. to Differential Equations	A-91
MA206 Probability and Statistics	A-93
MA256 Advanced Probability and Statistics	A-95
IT105 Introduction to Computing and Information Technology	A-97
EV203 Physical Geography	A-99

1. ***Course number and name***
   MA364, Engineering Mathematics

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 0.0 ET, 3.0 MA)
   LESSONS: 40 @ 55 min (2.5 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   MAJ Daniel Meadows

4. ***Text book, title, author, and year***
   Zill, D.G., 2018, *Advanced Engineering Mathematics,* 6th edition, Jones & Bartlett Learning

5. Specific course information

a. Brief description of the content of the course
SCOPE: This course provides additional mathematical techniques and deepens the understanding of concepts in mathematics to support continued study in science and engineering. Emphasis is placed upon using mathematics to gain insight into natural and man-made phenomena that give rise to problems in differential equations and vector calculus. Calculus topics focus on three-dimensional space curves, vector fields and operations, divergence and curl, and line and surface integrals. Analytic and numerical solutions to differential equations and systems of differential equations are found using a variety of techniques. Linear algebra topics include solutions to homogeneous and non-homogeneous systems of equations. An introduction to classical partial differential equations is also included.

b. Prerequisites or co-requisites
MA205

c. Required, elective, or selected elective
Required

6. Specific goals for the course

a. Specific outcomes of instruction.

i. Applying vector calculus to model and solve problems related to vector fields and vector differential and integral equations.
ii. Modeling with, solving, and interpreting the solutions of ordinary differential equations.
iii. Modeling with and solving first and second-order linear equations, applying linear transformations, and interpreting their solutions.
iv. Modeling with, solving, and interpreting the solutions of classical partial differential equations, such as the heat and wave equations.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	1
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	1
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	2
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	2
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. Brief list of topics to be covered

– Line integrals of scalar and vector fields
– Surface integrals of scalar and vector fields
– Green’s, Stoke’s and Divergence Theorem
– Geometry of the complex plane; arithmetic with complex numbers
– Classify differential equations by type, order, linearity, and homogeneity
– Model and solve physical systems with 1st and 2nd order ODEs (e.g., heating/cooling, exponential decay, spring-mass systems, and series circuits)
– Solve a nonlinear ODE using a Taylor series expansion
– Solve 2nd order linear constant coefficient nonhomogeneous ODEs using the method of undetermined coefficients
– Solve ODEs with continuous and discontinuous inputs using Laplace transforms
– Express functions as linear combinations of sines and cosines using Fourier series
– Process for solving a partial differential equation model using separation of variables
– Solve one-dimensional heat and wave equations with various initial and boundary conditions

1. ***Course number and name***
   MA365, Advanced Engineering Mathematics

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 0.0 ET, 3.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   LtCol Kristopher Ahlers

4. ***Text book, title, author, and year***
   Advanced Engineering Mathematics, 6th ed. by Dennis Zill, Jones and Bartlett Learning, Burlington, Massachusetts, 2018.

5. ***Specific course information***
   - ***a. Brief description of the content of the course***
     SCOPE: This is a course designed for the advanced mathematics student that has completed courses in differential equations and vector calculus and will study Mechanical Engineering, Electrical Engineering, Nuclear Engineering, Physics or Space Science. MA365 begins where the advanced mathematics program ends. This advanced engineering course offering includes topics in linear algebra, complex variables, Fourier series, partial differential equations, and computational mathematics. Applying mathematics consists of formulating and solving mathematical problems as well as interpreting and explaining results. Applied Mathematics is the language of engineering and the applied sciences. The goal is to provide students a solid foundation in mathematical reasoning and problem solving.
   - ***b. Prerequisites or co-requisites***
     MA153, Mathematical Modeling and Introduction to Differential Equations;
     MA255 Advanced Multivariable Calculus
   - ***c. Required, elective, or selected elective***
     Required

6. ***Specific goals for the course***
   - ***a. Specific outcomes of instruction.***
     - i. Developing mathematical differential equations to model specific systems of behavior
     - ii. Establishing valid and necessary assumptions for these systems and evaluating these assumptions by discussing how these assumptions affect their solution
     - iii. Interpreting the results of the mathematical techniques used to solve systems of equations and reflecting appropriately given the real-world scenario being studied
     - iv. Communicating technical breadth and thought through both written and oral presentations

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	2
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	1
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	2
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. Brief list of topics to be covered

- Linear Algebra
- Error analysis and convergence
- Fourier Series
- Partial Differential Equations
- Computational Methods
- Critical Reading Assessment

1. ***Course number and name***
   CH362, Mass and Energy Balances

2. ***Credit and contact hours***
   3.5 credit hours (ET=3.5 credit hours); LESSONS: 40 @ 55 min (2.5 Sessions/week), LABS: 7 @ 120 min.

3. ***Instructor's or course coordinator's name***
   MAJ Trevor Corrigan, M.S.

4. ***Text book, title, author, and year***
   Elementary Principles of Chemical Processes, Felder, Richard M., and Rousseau, Ronald W., Fourth Edition, John Wiley & Sons, New York: 2016.
   - ***a. Other supplemental materials***
     Fundamentals of Engineering Supplied Reference Manual, 9th Ed.
     Documentation of Academic Work by the Office of the Dean. West Point, New York: United States Military Academy, 2015.

5. ***Specific course information***
   - ***a. Brief description of the content of the course (catalog description)***
     SCOPE: Introduction to mass and energy balances in single phase and multiphase, nonreactive and reactive systems. Course topics include an introduction to engineering calculations and process variables, use of computers in solving chemical engineering problems, fundamentals of material balances in single-phase and multi-phase systems, energy balances on nonreactive and reactive processes, applications of combined material and energy balances, introduction to chemical engineering unit operations, and a general introduction to the field of chemical engineering.
   - ***b. Prerequisites or co-requisites***
     Pre-requisite: CH102 (General Chemistry II)
   - ***c. Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program***
     Required course

6. ***Specific goals for the course***
   - ***a. Specific outcomes of instruction.***
     - i. Understand how concepts learned in this course are relevant to contemporary chemical engineering industrial problems.
     - ii. Perform a degree of freedom analysis on a single or multiple unit process and evaluate whether the process is properly specified.
     - iii. Formulate and solve single and multiple unit mass balance equations on non-reactive processes.
     - iv. Formulate and solve single and multiple unit mass balance equations on reactive processes to include recycle and bypass systems.
     - v. Formulate and solve the energy balance equation for single and multiple units for non-reactive processes.
     - vi. Formulate and solve the energy balance equation for single and multiple units on reactive processes to include recycle and bypass streams.

vii. Use computer aided tools (Mathematica, MATLAB, and ChemCAD) to solve for mass and energy balance engineering problems.
viii. Effectively and clearly communicate technical information in oral and written form.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course
0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. [IFSAESM] Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	3
2. [DESIGN] Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	0
3. [COMMUNICATE] Communicate effectively with a range of audiences.	2
4. [PROF ETH/CONTEXT] Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	2
5. [TEAMS] Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	0
6. [EXPERIMENTS] Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	0
7. [KNOWLEDGE] Acquire and apply new knowledge as needed, using appropriate learning strategies.	2
8. Curricular outcomes: Material and energy balances [13] and thermodynamics [14]. Also, weak contributions in 16, 17, and 19.	3

7. ***Brief list of topics to be covered***
- Degree of freedom analyses on a single or multiple unit process
- Single and multiple unit mass balances on reactive and non-reactive processes
- Single and multiple unit energy balances on reactive and non-reactive processes

1. ***Course number and name***
   CH363, Separation Processes

2. ***Credit and contact hours***
   3.5 credit hours (ET=3.5 credit hours); LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 7 @ 120 min.

3. ***Instructor's or course coordinator's name***
   LTC Corey James

4. ***Text book, title, author, and year***
   Separations Process Principles, Seader, J.D., Henley, Ernest J., and Roper, D. Keith, Fourth Edition, John Wiley & Sons, New York: 2016.

5. ***Specific course information***
   a. Brief description of the content of the course (catalog description)
   SCOPE: This course covers methods for the physical separation of chemicals. Topics include dew point and bubble point calculations, adiabatic flash, distillation, chromatography, liquid-liquid and gas-liquid absorption. Students are taught the significance of staging of unit operations. Heavy emphasis is placed on theory of operation, numerical methods of solution, and simulation.
   b. Prerequisites or co-requisites
   Pre-requisite: CH362 (Mass and Energy Balances)
   c. Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program
   Required course

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Understand different thermodynamic equations of state used in equilibrium separation process simulations.
   ii. Formulate and solve material and energy balances for single and multistage separation processes.
   iii. Use ChemCAD to simulate distillation, absorption and extraction processes.
   iv. Understand the basic numerical algorithms for solving multicomponent equilibrium separation processes.
   v. Understand the theory, construction and operation of distillation and absorption columns.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. [IFSAESM] Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	3
2. [DESIGN] Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	2
3. [COMMUNICATE] Communicate effectively with a range of audiences.	3
4. [PROF ETH/CONTEXT] Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	0
5. [TEAMS] Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	0
6. [EXPERIMENTS] Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	1
7. [KNOWLEDGE] Acquire and apply new knowledge as needed, using appropriate learning strategies.	0
8. 12. - 20. Curricular outcomes: Separation processes [17]. Also, strong to medium contributions in 12 to 15, and weak contributions in 19 and 20.	3

7. ***Brief list of topics to be covered***
   - Introduction to separation processes
   - Thermodynamics of separation processes
   - Single equilibrium stages and flash calculations
   - Cascades and hybrid systems
   - Absorption and stripping of dilute mixtures
   - Distillation of binary mixtures

1. ***Course number and name:***
   CH383, Organic Chemistry I

2. ***Credit and contact hours***
   3.5 credit hours; LESSONS: 34 @ 80 min (2.5 Sessions/week), LABS: 15 @ 120 min.

3. ***Instructor's or course coordinator's name***
   Kamil Woronowicz, Ph.D.

4. ***Text book, title, author, and year***
   Organic Chemistry, 12th edition, by T.W. Graham Solomons, Craig B. Fryhle, and Scott A. Snyder, John Wiley & Sons, Inc. Hoboken, New Jersey, 2016.
   The Organic Chem Lab Survival Guide: A Student's Guide to Techniques; 10th Ed. by James W. Zubrick, John Wiley & Sons, Inc. Hoboken, New Jersey, 2015.

   a. Other supplemental materials
   Molecular visions: The Flexible Molecular Model Kit 3rd edition by Stephen D. Darling, McGraw Hill, New York, New York, 2006
   Documentation of Academic Work by the Office of the Dean. West Point, New York: United States Military Academy, 2017.

5. ***Specific course information***
   a. Brief description of the content of the course (catalog description)
   SCOPE: An introduction to the relationship between chemical structure and the physical and chemical properties of molecules. A qualitative description of structure and bonding is presented. The relationships between free energy changes and equilibria, and between activation energy and rate of reaction are developed. Stereochemistry and isomerism are explored. The concept of the mechanism of reaction is presented and the relationships between mechanism, the least energy path, stable intermediates and transition states are exemplified by the reactions of the alkanes, alkenes, alkyl halides and alcohols. The use of instrumental methods of structural analysis is also introduced.
   b. Prerequisites or co-requisites
   Prerequisites: CH102 or CH152* (Gen Chem II or Advanced Gen Chem II).
   *CH152 is no longer offered due to institutional changes starting with AY16
   c. Indicate whether a required, elective, or selected elective course: Required.

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Name organic molecules using the IUPAC system.
   ii. Determine spatial relationships within and between molecules.
   iii. Rationalize and describe trends in reactivity.
   iv. Write coherent mechanisms to explain or predict chemical transformations.
   v. Propose strategies to synthesize organic molecules.
   vi. Use spectroscopy to provide experimental evidence for the structure of molecules.
   vii. Apply basic laboratory techniques to safely synthesize, purify, and characterize organic molecules.

viii. Effectively and clearly communicate scientific information in written and oral form to a variety of audiences.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. [IFSAESM] Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	2
2. [DESIGN] Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	0
3. [COMMUNICATE] Communicate effectively with a range of audiences.	1
4. [PROF ETH/CONTEXT] Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	0
5. [TEAMS] Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	1
6. [EXPERIMENTS] Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	2
7. [KNOWLEDGE] Acquire and apply new knowledge as needed, using appropriate learning strategies.	1
8. Curricular Outcomes: Understand the chemical engineering curriculum, including: Chemistry. Also, weak contribution in Safety and environmental factors, Chemical reaction engineering, Continuous and staged separation processes, Modern experimental and computing techniques, and Process design.	3

7. ***Brief list of topics to be covered***

- Chemical structure and its relationship to physical properties of alkanes, alkenes, and alkynes, cycloalkanes, aromatics, alcohols and alkyl halides
- Reactivity of alkanes, alkenes, and alkynes, cycloalkanes, alcohols and alkyl halides
- Conformational analysis and stereochemistry
- Structural determination using NMR, IR, and Mass Spec
- Elimination, addition and nucleophilic substitution reactions
- Radical reactions and multistep synthesis
- Conjugation in dienes, allylic systems, and aromatic systems
- ACS exam

1. ***Course number and name***
   EE301, Fundamentals of Electrical Engineering

2. ***Credit and contact hours***
   3.5 credit hours (0.0 BS, 3.5 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2 Sessions/week), LABS: 7 @ 120 min.

3. ***Instructor's or course coordinator's name***
   Dr. Peter Hanlon

4. ***Text book, title, author, and year***
   Rizzoni and Kearns, 6th Edition, *Principles and Applications of Electrical Engineering*, McGraw Hill, Upper Saddle River, New Jersey.

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This introductory course in electrical engineering for the non-electrical engineering major provides a foundation in basic circuit theory and analysis, power in circuits and electric power systems, analog and digital electronics, and information technology systems. Lectures, laboratory work, practical applications, and classroom demonstrations emphasize and illustrate the fundamental theories and concepts presented in the course. Engineering design is reflected in laboratory work and minor design problems.
   b. Prerequisites or co-requisites
   Pre-requisites: MA205 (Calculus II)
   Co-requisites: PH202 (Physics II)
   c. Required, elective, or selected elective
   Required

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Develop an understanding of the fundamentals of electrical engineering.
   ii. Demonstrate the ability to solve electrical engineering problems.
   iii. Develop cadet's ability to participate in multi-disciplinary groups.
   iv. Enhance cadet's understanding of electrical and electronic systems in the Army.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	4
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	1
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	3
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	2
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***
   - Basic circuit theory
   - DC circuit analysis
   - First order circuits
   - AC circuit Analysis
   - AC power
   - Analog & Digital Electronics
   - IT / Communications

1. ***Course number and name***
   MC311, Thermal-Fluid Systems I

2. ***Credit and contact hours***
   3.5 credit hours (0.0 BS, 3.5 ET, 0.0 MA)
   LESSONS: 38 @ 75 min (2.5 Sessions/week), LABS: 2 @ 75 min.

3. ***Instructor's or course coordinator's name***
   MAJ Matt Miller

4. ***Text book, title, author, and year***
   Thermal-Fluid Systems, Daisie D. Boettner, 2016.

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: Thermal-Fluid Systems I is an integrated study of fundamental topics in thermodynamics and fluid mechanics. The course introduces conservation principles for mass, energy, and linear momentum as well as the 2nd Law of Thermodynamics. Principles are applied to incompressible flow in pipes and turbomachinery, power generation systems, refrigeration cycles, and total air-conditioning focusing on the control volume approach. Laboratory exercises are integrated into classroom work. This course includes completion of a comprehensive, out-of-class design problem. This design problem provides the opportunity for students to apply engineering science and the engineering design process to a hands-on project.
   b. Prerequisites or co-requisites
   Pre-requisite: CH101, MA205, PH201
   c. Required, elective, or selected elective
   Required

6. Specific goals for the course
   a. Specific outcomes of instruction.
   i. Determine the fundamental thermodynamic and physical properties of relevant solid materials, static fluids and fluid flows, to include ideal gases, liquids, steam, refrigerants and air-water vapor mixtures.
   ii. Apply static fluid principles to determine pressure variation effects within a fluid, forces on submerged surfaces, and surface tension effects.
   iii. Apply Conservation of Mass to Closed Systems and Control Volumes.
   iv. Apply Conservation of Momentum to Closed Systems and Control Volumes.
   v. Apply Conservation of Energy to Closed Systems and Control Volumes.
   vi. Apply principles of the 2nd Law of Thermodynamics to analyze performance limits on Closed Systems and Control Volumes.
   vii. Analyze and design new or improved existing thermal fluid systems using Conservation of Mass, Conservation of Energy, the 2nd Law of Thermodynamics, and cycle performance limits.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	4
3. an ability to communicate effectively with a range of audiences	4
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	3
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. Brief list of topics to be covered

- Hydrostatic Pressure: Manometry, submerged plane, submerged vessel, buoyancy, surface tension, capillary action
- 1st Law of Thermodynamics: Steady flow, energy equation, Bernoulli equation, Reynold’s Transport Theorem
- Vapor power Cycles: Steam properties, cycles, losses (2nd Law of Thermodynamics), steady flow devices, pipe flow, pipe networks and pumps
- Vapor Compression Refrigeration: Refrigerant properties, psychrometrics, air conditioning
- Conservation of mass, momentum, energy

1. ***Course number and name***
   CH364, Chemical Reaction Engineering

2. ***Credit and contact hours***
   3.5 credit hours (ET=3.5 credit hours); LESSONS: 40 @ 55 min (2.5 Sessions/week), LABS: 7 @ 120 min.

3. ***Instructor's or course coordinator's name***
   Dr. Enoch Nagelli

4. ***Text book, title, author, and year***
   Fogler, Scott H., *Elements of Chemical Reaction Engineering*, 5th Edition, Prentice Hall, 2016, ISBN: 978-0133887518.
   a. Other supplemental materials
   Documentation of Academic Work by the Office of the Dean. West Point, New York: United States Military Academy, 2017.

5. ***Specific course information***
   a. Brief description of the content of the course (catalog description)
   SCOPE: This course studies the effects of chemical reaction kinetics on systems of engineering significance. It introduces selection and operation of commercial chemical reactors, emphasizing chemical kinetics and transport phenomena. It studies currently practiced engineering techniques associated with each of these reactors. Topics covered in this course include ideal reactors including batch, CSTR and PFR, isothermal and nonisothermal. Other topics may include catalytic reactors, bioreactors, reactors, transient and steady state design, pressure drop in reactors, recycle, stability, and numerical methods.
   b. *Prerequisites or co-requisites*
   Prerequisites: CH362 (Mass and Energy Balances)
   c. *Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program*
   Required course

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Derive and manipulate mole and energy balances for batch, plug-flow, continuous stirred tank reactors and packed bed reactors.
   ii. Design and analyze isothermal reactors.
   iii. Design and analyze non-isothermal reactors at steady state.
   iv. Design and analyze systems with multiple reactions and/or multiple reactors.
   v. Interpret reactor rate data.
   vi. Derive rate equations from chemical mechanisms or experimental data.
   vii. Utilize computers in solving chemical engineering problems.
   viii. Introduction to chemical reactor design on CAD software.
   ix. Describe the steps in a catalytic reaction and the governing equations for each.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. [IFSAESM] Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	3
2. [DESIGN] Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	2
3. [COMMUNICATE] Communicate effectively with a range of audiences.	3
4. [PROF ETH/CONTEXT] Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	0
5. [TEAMS] Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	1
6. [EXPERIMENTS] Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	1
7. [KNOWLEDGE] Acquire and apply new knowledge as needed, using appropriate learning strategies.	2
8. Curricular Outcomes: Reaction engineering [8.6]. Also, strong to medium contributions in 1, 2, 9, and 10, and weak contributions in 3 and 4.	3

7. ***Brief list of topics to be covered***

- Isothermal reactor design (Batch, CSTR, PFR, and PBR)
- Determining rate laws from experimental data
- Isothermal reactor design for complicated/ multiple reactions
- Non-isothermal reactor design (Batch, CSTR, PFR, and PBR)
- Pseudo-steady state hypothesis
- Catalytic Reactor Design
- Capstone reactor design

1. ***Course number and name***
   CH367, Introduction to Automatic Process Control

2. ***Credit and contact hours***
   3.0 credit hours (ET=3.0 credit hours); LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   LTC Corey James

4. ***Text book, title, author, and year***
   Separations Process Principles, Seader, J.D., Henley, Ernest J., and Roper, D. Keith, Fourth Edition, John Wiley & Sons, New York: 2016.
   a. ***Other supplemental materials***
      Documentation of Academic Work by the Office of the Dean. West Point, New York: United States Military Academy, 2015.

5. ***Specific course information***
   a. ***Brief description of the content of the course (catalog description)***
      SCOPE: This course covers the principles necessary to understand the automatic control of chemical processes. Students learn the current mathematical models and mechanical details of various control elements, including sensors, transmitters, actuators, and controllers. Application of mathematical models will be covered with dynamic modeling techniques as well as real-time training using process simulators. The course will also cover tuning of controllers as well as safe response to process upsets. A capstone project will involve dynamic modelling of an integrated process control system.
   b. ***Prerequisites or co-requisites***
      Pre-requisite: EE301 (Introduction to Electrical Engineering), MA364 (Engineering Mathematics)
   c. ***Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program***
      Required course

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Understand different thermodynamic equations of state used in equilibrium separation process simulations.
      ii. Formulate and solve material and energy balances for single and multistage separation processes.
      iii. Use ChemCAD to simulate distillation, absorption and extraction processes.
      iv. Understand the basic numerical algorithms for solving multicomponent equilibrium separation processes.
      v. Understand the theory, construction and operation of distillation and absorption columns.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***

0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. [IFSAESM] Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	3
2. [DESIGN] Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	0
3. [COMMUNICATE] Communicate effectively with a range of audiences.	3
4. [PROF ETH/CONTEXT] Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	0
5. [TEAMS] Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	3
6. [EXPERIMENTS] Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	0
7. [KNOWLEDGE] Acquire and apply new knowledge as needed, using appropriate learning strategies.	0
8. Curricular outcomes: Separation processes [17]. Also, strong to medium contributions in 12 to 15, and weak contributions in 19 and 20.	3

7. ***Brief list of topics to be covered***

- Introduction to separation processes
- Thermodynamics of separation processes
- Single equilibrium stages and flash calculations
- Cascades and hybrid systems
- Absorption and stripping of dilute mixtures
- Distillation of binary mixtures

1. ***Course number and name***
   MC300, Fundamentals of Engineering Mechanics and Design

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 20 @ 75 min (1.25 Att/week), LABS: 10 @ 75 min.

3. ***Instructor's or course coordinator's name***
   Major David Flaherty

4. ***Text book, title, author, and year***
   Mechanics of Materials, 3rd Ed., by Timothy A. Philpot, John Wiley and Sons, Inc., 2013.

5. ***Specific course information***
   - ***a. Brief description of the content of the course***
     SCOPE: The engineering design process and the method of design are introduced. Principles of equilibrium are used to analyze forces on statically determinate rigid bodies and structures to include trusses and frames. The behavior of deformable bodies under axial and flexural loading is examined. The concepts of stress, strain, and material properties are introduced and are used to relate external forces applied to a body to the resulting internal forces and deformations so that performance can be evaluated. Practical applications involving the design and adequacy of mechanical and structural elements under various loading conditions are emphasized.
   - ***b. Prerequisites or co-requisites***
     Co-requisites: PH205/PH255 (Physics I)
   - ***c. Required, elective, or selected elective***
     Required

6. ***Specific goals for the course***
   - ***a. Specific outcomes of instruction.***
     - i. Describe and apply the engineering design process; solve engineering problems utilizing a methodical problem solving approach using appropriate technology.
     - ii. Apply equations of equilibrium to calculate external support reactions, internal pin reactions, and internal member forces for determinate 2D rigid bodies (i.e. trusses, simple connections, frames, machines, and beams).
     - iii. Develop, explain, and use a material's stress-strain curve and associated material properties.
     - iv. Draw the normal and shear stress distributions for structural members subjected to axial or flexural loads; calculate the maximum stresses.
     - v. Analyze and design axial members and beams based upon loading conditions and applicable criteria (i.e. normal or shear stress, critical buckling load, deformation/deflection.)
     - vi. Communicate technical information clearly through writing and drawing.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	1
3. an ability to communicate effectively with a range of audiences	5
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	5
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	5
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	5

7. Brief list of topics to be covered

- Principles: 1st and 2nd laws, 2D equilibrium, axial stress, axial strain, axial deformation, buckling, bearing stress, flexural stress, shear stress, deflection
- Design projects: Truss bridge and balsa beam
- Truss analysis
- Frame analysis
- Simple connections
- Shear and moment diagrams
- Beam design

1. ***Course number and name***
   MC312, Thermal-Fluid Systems II

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 35 @ 55 min (2.5 Sessions/week), LABS: 5 @ 55 min.

3. ***Instructor's or course coordinator's name***
   Lieutenant Colonel Andrew T. Bellocchio, PhD

4. ***Text book, title, author, and year***
   Boettner, D.D., 2013, *Thermal-Fluid Systems*, United States Military Academy.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      SCOPE: MC312 Thermal-Fluid Systems II continues the integrated study of fundamental topics in thermodynamics and fluid mechanics. The course applies conservation principles for mass, energy, and linear momentum as well as the 2nd Law of Thermodynamics. Principles are applied to an automotive system to examine engine performance (Otto and Diesel Cycles) and to high performance aircraft to examine the Brayton Cycle, compressible flow, external flow, lift, and drag. Laboratory exercises are integrated into classroom work. Design problems provide the opportunity for students to apply engineering science to the design of thermal-fluid systems.
   b. ***Prerequisites or co-requisites***
      Pre-requisites: MC311 (Thermal-Fluid Systems I)
   c. ***Required, elective, or selected elective***
      Required

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Design and conduct experiments, analyze and interpret data, and communicate the results to a general scientific audience.
      ii. Employ dimensional analysis and the Navier-Stokes equations to analyze external fluid flow.
      iii. Describe, classify, and perform Interior Ballistics (IB) engineering analysis on weapon systems.
      iv. Analyze the performance of gas turbine engines, to include compressible flow effects and exergy balance.
      v. Analyze the performance of internal combustion engines.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	3
3. an ability to communicate effectively with a range of audiences	5
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	5
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***

- Exergy balance of thermal-fluid systems.
- Introduction to internal combustion engines with a focus on the air standard Otto cycle, Diesel cycle, combustion, and enthalpy of formation
- Experimental methods that address uncertainty, dimensional analysis, similarity, and multi-sample uncertainty quantification
- External flow topics such as flow over a flat plate, boundary layer, drag, and lift
- Application of the differential approach to conservation of mass (continuity) and momentum (Navier-Stokes equations) in thermal-fluid systems
- Analysis of gas turbine engines using the Brayton Cycle, improvements to gas turbines, and aircraft propulsion of jet engines
- Compressible flow using stagnation properties, analysis of subsonic and supersonic nozzles and diffusers, and normal shock waves of supersonic flow
- Concentration on technical communication through three laboratory reports, peer review, oral poster presentation, and advanced topic presentation
- Design of Experiments using modeling and similarity with a focus on quantifying uncertainty and individual technical writing

1. ***Course number and name***
   CH365, Chemical Engineering Thermodynamics

2. ***Credit and contact hours***
   3.0 credit hours (ET=3.0 credit hours); LESSONS: 40 @ 55 min (2.5 Sessions/week), LABS: 0 @ 120 min.

3. ***Instructor's or course coordinator's name***
   Dr Andrew Biaglow

4. ***Text book, title, author, and year***
   Chemical Engineering Thermodynamics by J.M. Smith, H.C. Van Ness, M.M. Abbott, and M.T. Swihart, 8^{th} Edition, McGraw-Hill, New York, 2018.

5. ***Specific course information***
   a. Brief description of the content of the course (catalog description)
   SCOPE: This course covers the body of thermodynamic knowledge necessary for understanding modern chemical process simulation. Students learn the theory behind the thermodynamic methods used in the software. The course includes calculus- and numerical-based thermodynamics approaches for determining the properties of substances, solutions, and multiphase mixtures. Topics include equations of state, pure component properties, transport properties, properties of mixtures, fugacity, excess properties, activity coefficients, and phase equilibria. The problems in the course emphasize engineering applications. Topics covered in class are related to real systems through the use of chemical process simulators
   b. Prerequisites or co-requisites: Prerequisites: CH363, CH364, MA364, MC312
   c. Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program: Required course

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Understand how thermodynamic physical properties are calculated (and why is it important to be able to do so).
   ii. Understand the choices made by the CHEMCAD thermodynamics wizard and how to adjust them for specific cases.
   iii. Understand activity coefficients and why they are used.
   iv. Understand fugacity and fugacity coefficient and why they are used.
   v. Know which thermodynamic methods are best for an application.
   vi. Understand how an equation of state allows calculations of properties like enthalpy and entropy.
   vii. When substances are mixed together, know how the properties of the solution are calculated.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:*
0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	3
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	2
3. Communicate effectively with a range of audiences.	3
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	0
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	0
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	0
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	2
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	3

7. ***Brief list of topics to be covered***
- Introduction and fundamentals
- First Law
- Volumetric properties of pure fluids
- Second Law
- Properties of fluids
- Vapor-liquid equilibria
- Solution thermodynamics

1. ***Course number and name***
   CH459, Unit Operations Laboratory

2. ***Credit and contact hours***
   3.5 credit hours (ET=3.5 credit hours); LESSONS: 7 @ 120 min (3.0 Sessions/week), LABS: 40 @ 120 min.

3. ***Instructor's or course coordinator's name***
   LTC Matthew Armstrong, Ph.D.

4. ***Text book, title, author, and year***
   Unit Operations of Chemical Engineering, 7th Edition, by Warren L. McCabe, Julian C. Smith and Peter Harriott; McGraw-Hill, 2005.
   Plant Design and Economics for Chemical Engineers 5th edition, Peters, Max S. and Klaus D. Timmerhause, McGraw-Hill, New York 2003, ISBN-10: 0071240446, ISBN-13: 978-0071240444 (www.amazon.com 18 May 2010) Needed for safety class reference and process diagrams. Strength: HAZ Ops (p62-69), Process diagrams, symbols, and design.
   a. ***Other supplemental materials***
      Documentation of Academic Work by the Office of the Dean. West Point, New York: United States Military Academy, 2017.

5. ***Specific course information***
   a. ***Brief description of the content of the course (catalog description)***
      SCOPE: This course provides laboratory experience in selected chemical engineering unit operations, such as gas absorption, evaporation, distillation, liquid-liquid extraction, cooling tower, heat exchanger, and chemical reactors. Process control and process safety are emphasized in laboratory and classroom instruction. Written and oral reports required. (From Red Book Description on line 15 May 2013)
   b. ***Prerequisites or co-requisites***
      Pre-requisites: CH362 (Mass and Energy Balances), CH363(Separation Processes), CH364 (Chemical Reaction Engineering).
   c. ***Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program***
      Required course

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Learn how to apply the engineering thought process.
      ii. Continue the study of chemical engineering unit operations.
      iii. Use of computers for chemical engineering problem solving.
      iv. Learn to communicate effectively and clearly, in a precise scientific manner.
      v. Learn the basic principles of information technology as applied to chemical process engineering.
      vi. Learn to read and understand chemical engineering literature.
      vii. Understand laboratory and chemical safety.
      viii. Learn to design and conduct chemical engineering experiments.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. [IFSAESM] Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	3
2. [DESIGN] Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	2
3. [COMMUNICATE] Communicate effectively with a range of audiences.	3
4. [PROF ETH/CONTEXT] Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	0
5. [TEAMS] Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	3
6. [EXPERIMENTS] Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	3
7. [KNOWLEDGE] Acquire and apply new knowledge as needed, using appropriate learning strategies.	0
8. Curricular Outcomes: Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	3

7. ***Brief list of topics to be covered***

- Batch and continuous reactors
- Heat exchangers
- Gas absorption
- Hydrogen fuel cells
- Distillation
- Process control
- Cooling towers
- Centrifugal pumps
- Risk assessment, chemical hygiene, and HAZOPS
- Dimensional and error analysis

1. ***Course number and name***
   CH485, Heat and Mass Transfer

2. ***Credit and contact hours***
   3.5 credit hours (ET=3.5 credit hours); LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 7 @ 120 min.

3. ***Instructor's or course coordinator's name***
   LTC April Miller

4. ***Text book, title, author, and year***
   Mass and Heat Transfer, Russell, T.W.F., Robinson, A.S., and Wagner, N.J., Cambridge, New York 2008, ISBN 978-0-521-88670-3.
   a. *Other supplemental materials:*
   Documentation of Academic Work by the Office of the Dean. West Point, New York: United States Military Academy, 2012.

5. ***Specific course information***
   a. Brief description of the content of the course (catalog description):
   SCOPE: This course includes the study of the mechanisms of energy and mass transport, with special emphasis on applications in engineering systems. Coverage includes Fourier's Law of Heat Conduction, and Fick's Law of Diffusion, the development of shell energy and species balances, and the use of these equations to solve for temperature and concentration profiles in chemical engineering systems. An important emphasis in the course is the use of transport equations to understand species diffusion, convection, and chemical reaction in equipment.
   b. Prerequisites or co-requisites:
   Pre-requisites: MA364/5 and MC312.
   c. Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program:
   Required course

6. ***Specific goals for the course:***
   a. Specific outcomes of instruction:
   i. Learn a methodology for rational design and engineering analysis of problems in heat and mass transfer.
   ii. Model heat and mass transfer equations used to describe transport phenomena and be able to apply them to chemical engineering systems.
   iii. Determine heat and mass transport coefficients for the design of chemical engineering equipment.
   iv. Explain the mechanisms of heat and mass transfer in fluids and solids and apply them to engineering systems.
   v. Demonstrate ability to acquire and apply new knowledge to heat and mass transfer problems.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:***
0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. [IFSAESM] Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	3
2. [DESIGN] Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	1
3. [COMMUNICATE] Communicate effectively with a range of audiences.	2
4. [PROF ETH/CONTEXT] Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	2
5. [TEAMS] Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	0
6. [EXPERIMENTS] Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusion.	3
7. [KNOWLEDGE] Acquire and apply new knowledge as needed, using appropriate learning strategies.	1
8. Curricular outcomes: Heat, mass, and momentum transfer [d] and modern experimental and computing techniques [h].	3

7. ***Brief list of topics to be covered:***
   - Introduction to transport phenomena.
   - Steady state and transient mass, energy, and species balances, including chemical reactors, heat exchangers, and mass contactors.
   - Microscopic mass, energy, and species balances
   - Molar and thermal conduction and diffusion
   - Convective heat and mass transfer
   - Radiation heat transfer
   - Heat and mass transfer coefficients, including dimensional analysis
   - Interfacial phenomena.

1. ***Course number and name***
   CH400, Chemical Engineering Professional Practice

2. ***Credit and contact hours***
   1.5 credit hours (ET=1.5 credit hours); LESSONS: 20 @ 55 min (1.5 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   LTC Matthew Armstrong, Ph.D.

4. ***Text book, title, author, and year***
   a. Other supplemental materials:
   Documentation of Academic Work by the Office of the Dean. West Point, New York: United States Military Academy, 2017.
   b. FEPREP website

5. ***Specific course information***
   a. Brief description of the content of the course (catalog description):
   SCOPE: The course will meet once per week and will cover topics such as ethics, continuing education, and global and social issues within chemical engineering. Special emphasis will be placed on preparation for the Fundamentals of Engineering Exam using practice problems and graded practice exams. The course also covers professional plant engineering using plant simulators and mock exercises to teach proper troubleshooting and response techniques. (From Red Book Description in Curriculum Memo 1, Submitted October 2012, Approved January 2013)
   b. Prerequisites or co-requisites:
   Pre-requisites: CH102 or CH152 (General Chemistry).
   c. Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program:
   Required course

6. ***Specific goals for the course:***
   a. Specific outcomes of instruction:
   i. Understand the professional role of the chemical engineer.
   ii. Understand the chemical engineering curriculum and how it supports the role of the chemical engineer.
   iii. Appreciate the professional and ethical responsibilities of the chemical engineer.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:*
0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. [IFSAESM] Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	3
2. [DESIGN] Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	0
3. [COMMUNICATE] Communicate effectively with a range of audiences.	0
4. [PROF ETH/CONTEXT] Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	3
5. [TEAMS] Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	0
6. [EXPERIMENTS] Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	0
7. [KNOWLEDGE] Acquire and apply new knowledge as needed, using appropriate learning strategies.	3
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	3

7. ***Brief list of topics to be covered:***

- Introduction to the chemical industry.
- FE exam review to include topics such as professional ethics, organic chemistry, reaction engineering, thermodynamics, separations, and process control.
- Professional plant engineering to include plant operations such as review of control room simulators, operation of a fluid storage system, troubleshooting a cooling tower, troubleshooting a distillation column, and advanced operations.

1. ***Course number and name***
   CH402, Chemical Engineering Process Design

2. ***Credit and contact hours***
   3.5 credit hours (ET=3.5 credit hours); LESSONS: 40 @ 55 min (3.0 Sessions/week), LABS: 7 @ 120 min.

3. ***Instructor's or course coordinator's name***
   Andrew Biaglow

4. ***Text book, title, author, and year***
   Plant Design and Economics for Chemical Engineers 5th edition, Peters, Max S. and Klaus D. Timmerhause, McGraw-Hill, New York 2003, ISBN-10: 0071240446, ISBN-13: 978-0071240444.
   a. *Other supplemental materials:*
   Documentation of Academic Work by the Office of the Dean. West Point, New York: United States Military Academy, 2012.

5. ***Specific course information***
   a. Brief description of the content of the course (catalog description):
   SCOPE: This course provides a capstone experience that brings together material from previous courses to examine contemporary problems in chemical engineering process design. The course provides instruction in the conceptual design of processes to achieve design goals, as well as the economic optimization of the process. The course emphasizes the use of computer simulations, theory of unit operations, process control, safety, environmental and economic factors. The effect of changes in design on the process economics will be investigated. Written and oral design reports for the capstone design project are required. (From Red Book)
   b. Prerequisites or co-requisites: Pre-requisite: CH459, CH365, CH485
   c. Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program: Required course

6. ***Specific goals for the course:***
   a. Specific outcomes of instruction:
   i. Understand the development, synthesis, and use of chemical engineering processes.
   ii. Understand and be able to assess the economic potential of a chemical engineering process.
   iii. Understand the mechanical design of auxiliary chemical engineering equipment.
   iv. Use and understand chemical engineering process simulators.
   v. Write efficient and professional chemical engineering design reports.
   vi. Understand and be able to assess the various safety and environmental concerns encountered in the chemical process industry.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:

0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. [IFSAESM] Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	3
2. [DESIGN] Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	3
3. [COMMUNICATE] Communicate effectively with a range of audiences.	3
4. [PROF ETH/CONTEXT] Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	3
5. [TEAMS] Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	1
6. [EXPERIMENTS] Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	1
7. [KNOWLEDGE] Acquire and apply new knowledge as needed, using appropriate learning strategies.	3
8. Curricular Outcomes: Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, heat, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	3

7. ***Brief list of topics to be covered:***

- Transport and handling of fluids, including: pumps, compressors, expanders, agitators, flow measurement and storage of fluids, and piping design.
- Heat exchanger design, including general heat exchanger theory, heat exchanger types and costs, heat exchanger design with and without ChemCAD, optimum heat exchanger design.
- Chemical engineering economics, including cost estimation, capital investments, methods for estimating capital investments, revenue, production cost, and cash flow, interest, cash flow patterns and discount factors, taxes and fixed charges, profitability, and alternative investments.
- Process design and flow sheet development.
- Capstone design project.

1. ***Course number and name***
   EE360, Digital Logic with Embedded Systems

2. ***Credit and contact hours***
   3.5 credit hours (0.0 BS, 3.5 ET, 0.0 MA)
   LESSONS: 40 @ 55 min (2.5 Sessions/week), LABS: 8 @ 120 min.

3. ***Instructor's or course coordinator's name***
   MAJ Danny Z. Zhu, Ph. D.

4. ***Text book, title, author, and year***
   Digital Electronics: A Practical Approach with VHDL 9th edition, by William Kleitz, Pearson Prentice Hall: Upper Saddle River, New Jersey.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      This course covers the analysis, design, simulation, and construction of digital logic circuits and embedded systems. The material in this course provides the necessary tools to design digital hardware circuits such as digital clocks and locks, as well as computer hardware. The course begins with the study of binary and hexadecimal number systems, Boolean algebra, and their application to the design of combinational logic circuits. The first half of the course focuses on design using small-scale integration (SSI) logic circuits, medium-scale integration (MSI) circuits, and programmable logic devices (PLDs) to implement combinational logic functions. The second half of the course emphasizes sequential logic circuits like counters and sequence recognizers, and also covers memory systems. Laboratory work in this half of the course focuses on using very high-speed integrated circuit hardware description language (VHDL) to simulate digital systems and to program those systems into PLDs. As a final project, cadet teams design, build, and test a digital logic system.
   b. ***Prerequisites or co-requisites***
      Pre-requisites: IT105 (Introduction to Computing and Information Technology)
   c. ***Required, elective, or selected elective***
      Selected elective

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Design, build and test combinational logic circuits.
      ii. Design, build and test sequential logic circuits.
      iii. Understand and appreciate the fundamental principles and applications of digital subsystems found in computers, communications, and robotic systems.
      iv. Communicate design solutions in a logical manner, both orally and in writing.
      v. Integrate computer technology to design and simulate digital circuits.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	1
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	1
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

- Binary, Octal, Hexadecimal numbering Systems
- Combinational Logic Gates
- Boolean Algebra
- De Morgan’s Theorem
- Karnaugh Maps
- Binary Arithmetic
- Programmable Logic Devices
- Flip Flops, Latches and Registers
- Sequential Circuit Design
- Finite State Machines
- Microprocessor Fundamentals

1. ***Course number and name***
   EE377, Electrical Power Engineering

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 36 @ 55 min (2.5 Sessions/week), LABS: 4 @ 120 min.

3. ***Instructor's or course coordinator's name***
   Jack Cooperman

4. ***Text book, title, author, and year***
   Stephen J. Chapman, *Electric Machinery and Power System Fundamentals*, McGraw-Hill Companies, New York, NY 10020. ISBN: 0-07-229135-4.

5. ***Specific course information***
   a. Brief description of the content of the course
   EE377 provides a study of the fundamentals in three areas of electric power engineering: electromechanical energy conversion, electric power systems, and power electronics. Steady state behavior in single-phase and balanced three phase systems are emphasized. Transformers, AC and DC machines, transmission lines, power systems, rectifiers, and inverters are studied. Laboratory exercises demonstrate the electrical, mechanical, and physical characteristics of many of the devices studied.
   b. Prerequisites or co-requisites
   Pre-requisites: EE301 (Fundamentals of Electrical Engineering) or EE302 (Introduction to Electrical Engineering)
   c. Required, elective, or selected elective
   Selected elective

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Understand and appreciate the fundamental principles and applications of single and balanced three phase AC circuits and synchronous and DC machines.
   ii. Develop circuit models and analyze the steady state behavior of single and three phase AC circuits, rotational and translational electromechanical machines, AC power systems, and rudimentary converters.
   iii. Continue to develop problem solving skills and design simple transformer banks, AC transmission lines, simple electromechanical machines and simple power supplies.
   iv. Develop laboratory techniques using AC circuits and electromechanical machines as the topic of study.
   v. Develop oral and written communications skills and continue to develop the cadet's ability to prepare technical reports.
   vi. Integrate computer technology to analyze and design AC and DC circuits and to compute power flow.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	3
3. an ability to communicate effectively with a range of audiences	4
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	5
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***
- Ampere's law and modeling magnetic systems
- Faraday's law and single-phase power
- Three phase power
- Ideal and non-ideal single and three phase transformers
- Modeling with MATLAB's Simulink Simscape Electrical and PowerWorld
- AC machines power flow and losses
- Synchronous generators and motors
- Parallel operation of generators
- Brushed and brushless DC motors
- Transmission Lines
- Power Flow analysis
- Batteries
- Power Electronics

1. ***Course number and name***
   EM411, Project Management

2. ***Credit and contact hours***
   3.5 credit hours (0.0 BS, 3.5 ET, 0.0 MA)
   LESSONS: 35 @ 75 min (2.5 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***

MAJ Matthew J. Beigh

4. ***Text book, title, author, and year***
   Project Management: A Strategic Managerial Approach, 10th Edition, by Jack R. Meredith, Scott M. Shafer, and Samuel J. Mantel Jr., John Wiley and Sons, Inc., New York, 2018.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      SCOPE: This course develops skills required to lead an organization to the achievement of their objectives through the proper application of the management of planning, implementing and controlling the organization activities, personnel and resources. The course focuses on the Implementation phase of the Systems Decision Process (SDP). Topics include project selection, roles and responsibilities of the project manager, planning the project, budgeting the project, scheduling the project, allocating resources to the project, monitoring and controlling the project, evaluating and terminating the project, risk assessment and management, organizational structure and human resources. Case studies illustrate problems and how to solve them. Course assignments are designed to help students learn and apply project management techniques taught in the course. The class design project will provide students with the opportunity to integrate project management software, Microsoft Project, into the preparation of an Engineering Management Project Plan.
   b. ***Prerequisites or co-requisites***
      None
   c. ***Required, elective, or selected elective***
      Selected elective

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Identify project management practices used in current organizations.
      ii. Identify and describe the necessary qualities and skills required of successful project managers.
      iii. Be able to successfully plan, schedule, resource, monitor, control, terminate, and audit a wide array of projects.
      iv. Identify and utilize project management standards implemented by the Project Management Institute through the Project Management Body of Knowledge.
      v. Utilize Microsoft Project 2013© as an effective tool in managing successful projects.
      vi. Utilize case studies to bridge the gap between project management theory and practice.
      vii. Exercise oral and written communications skills.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	2
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	4
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	3
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	5
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	1
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	2

7. ***Brief list of topics to be covered***

- Introduction to Project Management, including defining the role, importance, and some key tools of project management.
- Project Initiation, which covers understanding the project management organization and the project manager, project selection methods, and conflict and negotiation techniques.
- Project Planning, which is focused on techniques to improve cost and duration estimates, creating a project budget and schedule, and explore issues related to project scheduling, resourcing, and risk management.
- PERT, CPM, project uncertainty, simulation, resource loading and leveling, and allocating scarce resources.
- Project Execution, including project monitoring, project control, auditing, and termination.

1. ***Course number and name***
   EM420, Production Operations Management

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   MAJ Steven Hoak

4. ***Text book, title, author, and year***
   Operations and Supply Chain Management, by Roberta S. Russell and Bernard W. Taylor III, Wiley & Sons Inc., 2017. 9th Edition with the online assessment tool WileyPlus

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This course deals with the quantitative aspects of design and analysis of production operations management. Emphasis is on identification, analysis, and solution of production problems using applied quantitative techniques. Practical exercises reinforce the problem-solving techniques necessary for today's successful military and civilian engineering managers and systems engineers. Specific methods and techniques taught and applied are operations strategy, product design and selection, total quality management, capacity planning, facility location, facility layout, work system design, lean systems and scheduling. This course is required for those pursuing the Engineering Management major and an elective for the Systems Engineering, Systems and Decision Sciences, Management and other engineering majors.
   b. Prerequisites or co-requisites
   Pre-requisites: MA206 (Probability & Statistics)
   c. Required, elective, or selected elective
   Selected elective

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Analyze and make operations management recommendations to a client with appropriate technology and engineering management tools.
   ii. Given a brief scenario description, describe the operations management mission, strategy, and competitive advantage of the business.
   iii. Given a brief scenario description, identify and assess statistical quality control problems and apply the appropriate tools to solve them.
   iv. Given a brief scenario description, identify and apply the appropriate techniques and tools to complete good product and service design.
   v. Given a brief scenario description, identify and assess facility location, layout and capacity issues and apply the appropriate tools to solve them.
   vi. Given a brief scenario description, identify and assess job design and work measurement problems and apply the appropriate tools to solve them.
   vii. Given a brief scenario description, identify and assess personnel, materials, and job scheduling issues and apply the appropriate tools to solve those issues.

viii. Given a brief scenario description, identify and assess queuing type problems and apply the appropriate tools to solve those issues.
ix. Given a brief scenario description identify and assess quality management of production of goods and services.
x. Communicate in oral or written reports the analysis and application of course concepts to real-world scenarios.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	4
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	4
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	1
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	3
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

– Principles: Evolution of operations and supply chain management, globalization, productivity, production's impact on a firm's strategy, decision making under uncertainty and under risk, Total Quality Management, Lean Six Sigma, quality costs, Statistical Process Control, acceptance sampling, production and service design, queueing, capacity planning, facility layout and location modeling, job design and ergonomics, learning curves, and scheduling.

1. ***Course number and name***
   EM481, Systems Simulation

2. ***Credit and contact hours***
   3.5 credit hours (0.0 BS, 3.5 ET, 0.0 MA)
   LESSONS: 35 @ 75 min (2.1 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   MAJ Stephen McCarthy

4. ***Text book, title, author, and year***
   Simulation Using ProModel, by Harrell, C., Biman, G., & Bowden, R., McGraw-Hill Companies, Inc., New York. 2012. 3rd Edition.

5. ***Specific course information***
   - ***a. Brief description of the content of the course***
     SCOPE: through this course, cadets will learn and explore discrete event simulation techniques used to analyze and improve complex systems. Applications for discrete event simulation include manufacturing, transportation, logistics, and service systems. Topics include the simulation study process, queuing theory, input data analysis, generation and testing of random numbers, simulation construction, verification and validation of simulation models, and output analysis. Cadets will demonstrate proficiency of lesson objectives while developing communication skills through graded events, a comprehensive course project, and an interactive classroom and lab environment. Upon completion of the course, cadets will be able to simulate and analyze moderately complex civilian and military systems.
   - ***b. Prerequisites or co-requisites***
     M206 or MA256
   - ***c. Required, elective, or selected elective***
     Selected Elective

6. ***Specific goals for the course***
   - ***a. Specific outcomes of instruction.***
     - i. Understand the process of conducting a simulation study.
     - ii. Understand the application of closed form analytical queuing methods when conducting a simulation study.
     - iii. Demonstrate the ability to generate and test sequences of pseudo-random numbers and selected classes of random variates.
     - iv. Collect, analyze, and determine the appropriate probability distribution for data used in a simulation study (input modeling analysis).
     - v. Demonstrate comprehension of the simulation modeling process and be able to construct a simulation using course software.
     - vi. Verify and validate simulation models.
     - vii. Evaluate and interpret the quantitative output of simulation experiments for both single system and multiple systems (output analysis).
     - viii. Demonstrate the ability to design, conduct, and analyze simulation experiments using a simulation package.

ix. Prepare and brief a written analysis of a design problem supported by simulation results.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	3
3. an ability to communicate effectively with a range of audiences	2
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	3
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	5
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***

- Queuing: queue utilization, Kendall’s notation, evaluation measures of M/M/1, G/G/1, and G/G/s queuing models
- Modeling Random Behavior: Random Number Generation (RNG), distribution fitting, testing for independence and identical distribution
- Statistics: Conducting hypothesis tests, Poisson and Exponential distributions, finding basic descriptive statistics
- System Modeling: drawing an entity flow diagram
- ProModel Proficiency: Using Stat:Fit, LEAP model building process, building a discrete-event simulation using ProModel commands and logic, verifying and validating simulation models.

1. ***Course number and name***
   MC306, Dynamics

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 40 @ 55 min (2.5 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   MAJ Joseph Cymerman

4. ***Text book, title, author, and year***
   Tongue, B., 2010, *Dynamics Analysis and Design of Systems in Motion, 2nd ed.* New York, John Wiley & Sons.

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: Dynamics examines the motion of particles, systems of particles, and rigid bodies under the influence of forces. It focuses on the use of Newton's Second Law, in three major, progressive blocks of instruction from scalar, then vector, treatments of rectilinear and curvilinear motion of single particles; through vector motion of systems of particles; to general three-dimensional motion of rigid bodies. The course also provides brief introductions to energy methods: work-energy and impulse-momentum.
   b. Prerequisites or co-requisites
   Co-requisites: MC300 (Fundamentals of Engineering Mechanics and Design)
   Pre-requisites: PH201 (Physics I), PH206 (Physics II)
   c. Required, elective, or selected elective
   Selected elective

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Describe the physical concepts behind, and determine mathematically the products of, scalar and vectors operations.
   ii. Determine the time-based relationships among orientation, position, velocity, and acceleration.
   iii. Describe the physical meaning and approximations behind, and calculate inertial properties for, particles, systems of particles, and rigid bodies.
   iv. Categorize and calculate the forces acting on an object.
   v. Apply Newton's Laws to generate the three-dimensional equations of motion for particles, systems of particles and/or rigid bodies.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	**Level**
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	1
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	2
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

- Scalar and Vector Mathematics
- Position Vectors and Vector Geometry
- Vector Bases, Coordinate Systems, and Rotation Matrices
- Vector Differentiation and Reference Frames
- Angular Velocity and Angular Acceleration
- Kinematics of Particles/Points: Velocity & Acceleration
- Forces and Moments
- Linear and Angular Momentum of a Particle
- Kinetics of Particles and Solving Equations of Motion
- Linear/Angular Momentum and Impulse & Collisions
- Kinetic and Potential Energy (Particles)
- Moments and Products of Inertia of a Particle and a Rigid Body
- Constraints: Connectors and Connections
- Instantaneous Centers of Rotation and Contact Constraints
- Applications of the Laws of Motion

1. ***Course number and name***
   MC364, Mechanics of Materials

2. ***Credit and contact hours***
   3.5 credit hours (0.0 BS, 3.5 ET, 0.0 MA)
   LESSONS: 25 @ 75 min (1.560 Att/week), LABS: 10 @ 75 min.

2. ***Instructor's or course coordinator's name***
   Dr. Elizabeth Bristow

4. ***Text book, title, author, and year***
   Mechanics of Materials, 3rd Ed., by Timothy A. Philpot, John Wiley and Sons, Inc., 2013.

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This course studies the behavior of a variety of materials under normal, shear, torsional, bending and combined loads. The concepts of stress, strain, failure theory and failure mechanisms are explored. The loading, geometry, functional environment and material properties of machine or structural parts are used to relate the forces applied to a body to the resulting internal forces and deformations so that performance can be evaluated. Practical applications involving the design and adequacy of mechanical and structural elements under various loading and environmental conditions are emphasized. The course includes several laboratory experiences that require students to develop and conduct experiments, analyze and interpret data, and use engineering judgement to draw conclusions.
   b. Prerequisites or co-requisites
   Co-requisites: MA205/MA255/MA366
   Pre-requisites: MC300
   c. Required, elective, or selected elective
   Selected elective

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Calculate the internal forces, internal stresses, and deformations of axially loaded members, circular members in torsion, thin-walled pressure vessels, prismatic beams in bending, columns, and members subjected to combined loading and/or thermal effects.
   ii. Apply compatibility of deformations to analyze and design members of a statically indeterminate structure subjected to loading and/or thermal effects.
   iii. Apply appropriate theories of failure to analyze and design thin-walled pressure vessels and members subjected to loading and/or thermal effects.
   iv. Given strain data from a strain rosette, determine the state of strain and the state of stress.
   v. Given a state of stress at a point, determine the principle stresses, the maximum in-plane shear stress, the angle to the principal plane, and the state of stress on any plane.
   vi. Apply deformation—strain, strain—stress, and stress—force relationships to analyze and design structural members and machine components.

vii. Conduct laboratory experiments to verify and apply methods, theories and scientific laws learned throughout the course, and prepare proper technical reports to clearly communicate the conduct and results of those experiments.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	1
3. an ability to communicate effectively with a range of audiences	5
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	5
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	5
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

- Statically indeterminate axially loaded members
- Torsion
- Shear and moment diagrams
- Beam deflection by integration
- Statically indeterminate beams
- Stress transformation
- Combined loaded members

1. ***Course number and name***
   MC380, Engineering Materials

2. ***Credit and contact hours***
   3.5 credit hours (0.0 BS, 3.5 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2 Sessions/week), LABS: 5 @ 75 min.

3. ***Instructor's or course coordinator's name***
   Dr. Kenneth J. McDonald

4. ***Text book, title, author, and year***
   Callister and Rethwich, Materials Science and Engineering, 9th Edition

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      Course explores the relationship between the microscopic structure and macroscopic properties of materials used in engineering applications. The origin of mechanical and physical properties is studied. Emphasized is an understanding of the fundamental aspects of atomic and microstructural concepts for proper materials selection and enhancement of engineering properties. Materials under study are metals, ceramics, polymers, composites, nano-sized/structured materials, biomaterials, smart materials, and semi- and super-conductors. Laboratory exercises are incorporated throughout the course to provide practical experience in making decisions concerning material composition and processing in order to optimize engineering properties. Experiences from the field are detailed to demonstrate application of concepts.
   b. ***Prerequisites or co-requisites***
      Pre-requisites: MC300 (Fundamentals of Engineering Mechanics and Design)
      And CH102 (General Chemistry II)
   c. ***Required, elective, or selected elective***
      Selected elective

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Describe and contrast the classes of engineering materials in terms of general microstructure, properties, failure mechanisms and application (metals, ceramics, polymers, composites, biomaterials, nanomaterials, and smart materials).
      ii. Determine how the atomic structure of materials influences physical and mechanical properties.
      iii. Distinguish between microstructures utilizing isomorphous and eutectic phase diagrams to compute phases, compositions and amounts of elemental constituents.
      iv. Analyze processing and strengthening mechanisms to optimize physical and mechanical properties.
      v. Apply materials science concepts and knowledge to the proper selection of engineering materials.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***
- Bonding
- Crystallography
- Defects/Slip/Strengthening Mechanisms
- Diffusion
- Phase Diagrams – Binary Isomorphous, Binary Eutectic, Fe/Fe_3C
- Phase Transformation Dynamics
- Heat Treatment of Steel, Time Temperature Transformation (TTT)/Continuous Cooling Transformation Diagrams(CCT)
- Manufacturing and Mechanical Behavior of Metals
- Polymers – Structure, Molecular Weight, Crystallinity, Glass Transition Temperature, Manufacturing, and Mechanical Behavior
- Ceramics – Types, Properties, Defects, Manufacturing, and Mechanical Behavior
- Composites – Types, Rules of Mixtures, Manufacturing, and Mechanical Behavior
- Corrosion – Electrochemistry, Types, and Prevention
- Semi- and Super- Conductors
- Economic, Environmental, and Societal Effects of Materials
- Ashby Diagrams

1. ***Course number and name***
   ME472, Energy Conversion Systems

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   Dr. Gunnar Tamm

4. ***Text book, title, author, and year***
   Boettner, D.D., 2013, *Thermal-Fluid Systems*, United States Military Academy.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      SCOPE: Fundamental concepts are extended to the engineering analysis of coal, oil and natural gas fossil fuel systems to assess the dominant sources of energy and technologies in the electric power, transportation, industrial, and residential and commercial energy sectors. Renewable and alternative energy resources including solar, wind, biomass, hydro, geothermal, nuclear and ocean energy are assessed, along with analysis of conventional and emerging technologies to harness them. National and global energy issues are discussed with technical, economic, environmental, societal and geopolitical considerations and in the context of Army energy needs.
   b. ***Prerequisites or co-requisites***
      Pre-requisites: MC311 (Thermal-Fluid Systems I)
   c. ***Required, elective, or selected elective***
      Selected elective

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Describe the evolution of fossil fuel resources and analyze their associated technologies within the limits of realistic constraints.
      ii. Describe the evolution of renewable and alternative energy resources and analyze their associated technologies within the limits of realistic constraints.
      iii. Explain national and global energy issues with consideration of technical, economic, environmental, societal and geopolitical factors and in the context of Army energy needs.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	3
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	4
3. an ability to communicate effectively with a range of audiences	2
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	4
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	1
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	3
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

- Principles: 1st and 2nd laws, heat transfer, combustion, flame temperature, chemical exergy, chemical equilibrium, engineering economics, solar positioning, photovoltaic effect
- Technologies: Fuel cells, batteries and energy storage, Rankine, IGCC, Otto, Diesel, Stirling, solar thermal power, solar PV, solar hot water, solar collectors, electric vehicles, clean coal, carbon capture, power grid, wind turbines, hydroturbines
- Fossil fuel sources: coal, oil, natural gas, shale oil, tar sands, methane hydrates
- Renewable/alternative energy sources: nuclear, solar, wind, hydro, ocean, wave, biomass, current, tidal
- Issues: Geopolitical, environmental, economic, societal, climate change
- Energy in the context of the Army, U.S. and World
- Design project: PV and Solar Hot Water system for the home using fundamental modeling techniques and NREL modeling software

1. ***Course number and name***
   ME480, Heat Transfer

2. ***Credit and contact hours***
   3.5 credit hours (0.0 BS, 3.5 ET, 0.0 MA)
   LESSONS: 40 @ 55 min (2.5 Sessions/week), LABS: 8 @ 120 min.

3. ***Instructor's or course coordinator's name***
   Captain Briana D. Fisk, MS

4. ***Text book, title, author, and year***
   Bergman, T.L., and Lavine, A.S., 2017. *Fundamentals of Heat and Mass Transfer, 8th ed*. New York, John Wiley & Sons.

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: The three modes of heat transfer, conduction, convection, and radiation, are studied in detail and applications are made to various engineering systems. The principles of conduction and convection are used to study the mechanisms of heat transfer during boiling, condensation and the design of heat exchangers.
   b. Prerequisites or co-requisites
   Pre-requisites: MC311 (Thermal-Fluid Systems I), MA364 (Engineering Mathematics) or MA365 (Advanced Math for Engineers/Scientists)
   c. Required, elective, or selected elective
   Selected elective

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Apply the principles of conduction heat transfer under steady and transient conditions using analytical and numerical techniques.
      ii. Apply the principles of convection heat transfer for natural and forced flows in internal and external configurations.
      iii. Apply the principles of radiation heat transfer for blackbodies and real surfaces.
      iv. Design and analyze heat transfer devices using combined conduction, convection and radiation principles.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	3
3. an ability to communicate effectively with a range of audiences	2
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	3
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	5
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

- Solution Techniques using the Heat Diffusion Equation for 1-D and 2-D Steady, 1-D Steady with Generation
- Thermal Circuits for Plane Walls, Cylinders, Spheres, and Extended Surfaces
- Lumped Capacitance and 1-D Transient Conduction
- Numerical Methods for Steady and Transient Conduction
- Hydrodynamic and Thermal Boundary Layers
- Poiseuille, Couette Flow, and Internal Flow Correlations
- Blasius’ Solution and External Flow Correlations
- Free Convection
- Boiling and Condensation
- Heat Exchangers: LMTD and Effectiveness-NTU Methods
- Blackbody, Real Surface Radiation, View Factors, and Radiation Exchange
- Multimode Heat Transfer
- Thermal Modeling in MATLAB and SolidWorks
- Laboratory Exercises focused on Internal Convection and Conduction through an Extended Surface

1. ***Course number and name***
   ME491, Automotive Engines

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 5 @ 75 min.

3. ***Instructor's or course coordinator's name***
   MAJ Patrick Linford (Course Director), Dr Vikram Mittal, CPT Mark Lesak

4. ***Text book, title, author, and year***
   a. Ferguson, Colin R. and Allan T. Kirkpatrick. Internal Combustion Engines: Applied Thermoscience, Third Edition. Wiley & Sons, United Kingdom. ISBN 978-1-118-53331-4.
   b. Department of the Army. TM 9-8000 Principles of Automotive Vehicles. HQDA, 1985. (available for download at https://www.logsa.army.mil/etms)

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: Students engage in the analysis, testing, and evaluation of internal combustion engines and their subsystems with a goal toward understanding the principles affecting performance and efficiency. Spark ignition and compression ignition engine systems are studied in detail, with laboratory events designed to connect theory and practice. A series of design problems is interspersed throughout the course along with a semester long engineering design project.
   b. Prerequisites or co-requisites
   Pre-requisite: MC311 (Thermal-Fluid Systems I)
   Co-requisite: MC312 (Thermal-Fluid Systems II)
   c. Required, elective, or selected elective
   Selected elective

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Describe, classify, and perform basic calculations on internal combustion engine performance parameters such as torque, power, specific fuel consumption, and mean effective pressure.
   ii. Predict engine performance parameters based on Ideal, Fuel-Air and Actual engine cycles using theoretical and experimental values to include in-cylinder pressure data.
   iii. Explain and measure engine parameters with laboratory and/or vehicle integrated diagnostic equipment to determine performance, efficiency, and emissions.
   iv. Describe and calculate engine friction, heat transfer, and combustion.
   v. For a 2 or 4-stroke engine cycle, explain and calculate the processes and components involved in fuel supply and gas flows.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	4
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

- Engine cycles: Standard and CASA Otto and Diesel cycles, Miller cycles
- Stoichiometry of automotive fuel combustion
- Engine Control Systems
- Engine Friction: pistons, rings, valvetrain
- Intake and exhaust flow: naturally aspirated and forced induction
- Ignition systems and combustion
- Heat Transfer modeling and analysis
- Emissions

1. ***Course number and name***
   NE300, Fundamentals of Nuclear Engineering

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 1 @ 75 min.

3. ***Instructor's or course coordinator's name***
   CPT(P) R. Boone Gilbreath, Course Director

4. ***Text book, title, author, and year***
   Fundamentals of Nuclear Science and Engineering, 3d ed., J. Kenneth Shultis and Richard E. Faw, 2017, CRC Press
   Nuclides and Isotopes: Chart of the Nuclides, 17th ed., Edward M. Baum, et al., 2009, Bechtel Marine Propulsion Corporation.

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This course provides the student with an understanding of the fundamental physical principles involved in radioactive decay, radiation interaction with matter, nuclear fission and the nuclear fuel cycle. The course covers neutron interactions with matter, fission, neutron diffusion, neutron moderation, and reactor criticality. This course is essential for the nuclear engineer and is an excellent choice for the applied scientist.
   b. Prerequisites or co-requisites
   Co-requisites: PH205/PH255 (Physics I)
   c. Required, elective, or selected elective
   Selected elective

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Define and discuss the various fundamental particle types.
   ii. Comprehend the various nuclear decay processes, types of nuclear reactions, and wave-particle duality.
   iii. Apply appropriate conservation laws to solve quantitative problems involving radioactive decay, nuclear reactions, mass-energy equivalence, and reaction energy.
   iv. Solve quantitative problems radiation interactions with matter, to include: number density, neutral and charged particle attenuation, scattering interactions, neutron lethargy, and reaction rates.
   v. Explain the theory of operation of various radiation detectors, and solve quantitative problems involving count rates, detector dead time, efficiency, resolution, and propagation of uncertainty.
   vi. Explain the basic function of a nuclear reactor including the fission process, the neutron life cycle, and the nuclear fuel cycle.
   vii. Solve quantitative problems involving nuclear reactor theory to include: fuel enrichment, multiplication factor calculations, fuel consumption rates, conversion and breeding, and system efficiency.

viii. Comprehend and communicate professional and ethical knowledge required of nuclear engineers when solving contemporary nuclear engineering problems with particular focus on relevant military applications of nuclear energy.

ix. Search out relevant scholarly publications and other credible published literature to synthesize and communicate (in written and/or oral form) the significance of a body of work to a specified topic in nuclear engineering.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	1
3. an ability to communicate effectively with a range of audiences	4
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	3
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	2
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***

- Atomic and Nuclear Physics
- Radiation Interactions with Matter
- Radiation Detection
- Nuclear Reactor Theory
- Nuclear Fuel Cycle

1. ***Course number and name***
   NE350, Radiological Engineering Design

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min

3. ***Instructor's or course coordinator's name***
   CPT Joshua Herrera

4. ***Text book, title, author, and year***
   Nuclear Energy, Raymond L. Murray and Keith E. Holbert, 2015, Elsevier

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This course focuses on nuclear engineering systems including radiation protection, shielding, and the uses of radioactive sources in industrial processes. Specific topics emphasize the operation of radiation detectors, shielding principles, health effects of radiation, radiological dispersion devices, and nuclear incidents. A design project applies the concepts presented in this course to the solution of practical problems.
   b. Prerequisites or co-requisites
   Pre-requisites: NE300 (Fundamentals of Nuclear Engineering)
   c. Required, elective, or selected elective
   Selected elective

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Understand the biological effects of ionizing radiation and design systems that incorporate radiation protection
   ii. Understand and implement the nuclear engineering design process and probabilistic risk assessment.
   iii. Understand how radiation detection devices function and how to interpret their outputs
   iv. Understand medical and industrial applications for radiation technology other than commercial power generation
   v. Understand multiplication, criticality, and the time dependence of neutron chain-reacting systems (i.e. nuclear reactors).
   vi. Understand the U.S. policy on classification, treatment, transportation, and disposal of radioactive waste, and potential improvements in the process

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	5
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	3
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***
Course Introduction and Design Process I, Charged Particle and Gamma-Ray Interactions, Biological Effects of Radiation, Radiation Protection I: External Radiation Exposure and Shielding, Radiation Protection II: Internal Radiation Exposure and Standards, Radiation Applications I: Information from Isotopes, Radiation Applications II: Treatment, Sterilization, and Transmutation, Reactor Safety, Security, and Lessons Learned, Probabilistic Risk Assessment, Design Process II, Radiation Detectors I: Gas Counters and Neutron Detectors, Radiation Detectors II: Scintillation Counters, Dosimeters, and Solid State Detectors, Radiation Detectors III: Statistics, Pulse Height Analysis, and Pre-Lab Activity, Laboratory Exercise and Lab Writing Workshop, Reactors I: Criticality, Multiplication, and Introduction to Reactor Kinetics, Prompt Jump Approximation, Reactivity Feedback, and Control, STERIS Trip Section, Nuclear Fuel Cycle I: Front End of the Commercial Fuel Cycle, Nuclear Fuel Cycle II: Back End of the Commercial Fuel Cycle, Design Project Briefs

1. ***Course number and name***
   NE450, Nuclear Weapons Effects

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   LTC Ronald C. Hasz

4. ***Text book, title, author, and year***
   The Effects of Nuclear Weapons, Samuel Glasstone and Philip J Dolan, 1977, Department of Defense

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This course focuses on the operation of nuclear and fusion weapons, and the effects of a nuclear weapon detonation. Specific topics emphasize blast effects, thermal radiation, initial radiation and fallout, electromagnetic pulse, biological effects of radiation, and the policy issues associated with weapons of mass destruction. Extension problems with design components apply the concepts presented in NE450 to the solution of practical problems.
   b. Prerequisites or co-requisites
   Co-requisites: NE300 (Fundamentals of Nuclear Engineering), PH206/PH256 (Physics II)
   c. Required, elective, or selected elective
   Selected elective

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Apply physical concepts and principles to solve relevant problems from radiation interaction with matter related to the design, prompt, and residual effects of nuclear weapons.
   ii. Comprehend empirical relationships and engineering tools used by the DOD nuclear weapons effects communities.
   iii. Communicate effectively, both verbally and in writing, the critical examinations and analysis of engineering problems.
   iv. Demonstrate knowledge of contemporary nuclear issues.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	3
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	1
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	4
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	3
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	1
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

- Nuclear fuel cycle focusing on gaseous diffusion, gaseous centrifuge, and electromagnetic isotope separation enrichment techniques.
- Nuclear weapon design focusing on energy yield, fission weapon mechanics, fusion, thermonuclear weapons.
- Nuclear weapons effects focusing on x-rays, thermal, air blast, underground shock, initial radiation, residual radiation, biological, electromagnetic pulse, computational tools (HPAC) and analysis of those effects.
- Nuclear weapon stockpile and proliferation, nonproliferation, counterproliferation history overview.

1. ***Course number and name***
   SE301, Fundamentals of Engineering Design & Systems Management

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 3.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   CPT Samuel Herbert

4. ***Text book, title, author, and year***
   Cabrera, Derek and Cabrera, Laura, *Systems Thinking Made Simple: New Hope for Solving Wicked Problems,* 2nd Edition, Odyssean, 2015.

   Parnell, Gregory S., Driscoll, Patrick J., Henderson, Dale L., *Decision Making in Systems Engineering and Management,* 2nd Edition, John Wiley & Sons, Inc., 2011**.**

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: SE301 serves as the "roadmap" course for all cadets taking the Engineering Management, Systems Engineering, and Systems & Decision Sciences majors as well as all cadets enrolled in the Core Engineering Sequence. This course presents the methodological framework and techniques for designing, implementing, managing and reengineering complex systems or processes. Cadets learn engineering design and engineering management processes and gain an appreciation for future environments and system life-cycles. Cadets analyze case studies and complete practice problems to illustrate mastery of course topics. Cadets also use spreadsheet software for modeling and analyzing design alternatives. SE301 introduces a Systems Decision Process while incorporating material from courses in the USMA core curriculum and also previews the modeling and decision-making tools that cadets will learn in follow-on Department of Systems Engineering courses. The course is designed to allow Cadets the opportunity to learn engineering design and engineering management processes on an individual level so that each Cadet will have the experience necessary to succeed in future Systems Engineering courses. Cadets will spend a number of lessons in a computer lab environment.
   b. Prerequisites or co-requisites
   MA206; MA256, MA206X
   c. Required, elective, or selected elective
   Selected elective

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Apply systems thinking and the Systems Decision Process (SDP) to design an engineered solution to a large-scale, complex, multi-disciplinary engineering problem.
   ii. Understand the four phases of the Systems Decision Process and perform the individual tasks in each phase to address an engineering problem.
   iii. Perform stakeholder and requirement analysis to ensure alternatives achieve the desired outcome and account for the political, social, and economic dimensions of an engineering problem.

- iv. Demonstrate creativity in the formulation of alternative solutions to an engineering problem.
- v. Apply Life Cycle Cost Analysis methods in comparing alternatives.
- vi. Apply mathematics, basic science, and engineering to analyze a physical system or process and apply the results to the solution of an engineering problem.
- vii. Understand the role of modeling and simulation in the development and analysis of an engineered solution to meet stakeholder requirements.
- viii. Communicate technical findings effectively, both orally and in writing.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	5
3. an ability to communicate effectively with a range of audiences	5
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	4
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	5
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	5
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***
   - Systems Thinking
   - Problem Definition and Solution Design
   - Decision Making and Solution Implementation
   - Course Project: Design and presentation of real-world engineering solution

1. ***Course number and name***
   SM484, System Dynamics Simulation

2. ***Credit and contact hours***
   3.5 credit hours (0.0 BS, 3.5 ET, 0.0 MA)
   LESSONS: 35 @ 75 min (0 Att/wk), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   MAJ Christine Krueger, Course Coordinator; CPT Travis Connell, Instructor

4. ***Text book, title, author, and year***
   Sterman, J.D., 2000, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, McGraw Hill.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      SCOPE: Simulation modeling can be used to study the effects of changes to existing systems or processes or evaluate the performance of new systems prior to their implementation. The techniques taught in this course are a significant part of the Systems Decision Process (SDP) as they introduce the concept of dynamic systems thinking and analysis. By their nature, large scale systems are dynamic. These systems involve complex cause and effect relationships that form feedback loops between the variables of interest. These systems produce outcomes that are not always intuitive. The cadets use the properties of dynamic systems and analytical techniques to design continuous models of complex systems or processes, implement these models, and perform an analysis of the results. Topics include applications of System Dynamics, client/modeler relationships, problem articulation, functional modeling through causal loop diagrams and stock and flow diagrams, modeling and simulation in a PC-based continuous event simulation package, policy design, policy testing, and policy implementation. These concepts and principles are applied to military and civilian applications such as physical systems, human decision processes, population, and economic/business processes. Cadets develop communication skills by presenting their design results in both written reports and oral presentations. The course also addresses ethical implications in the development and application of dynamic models as well as interactions with decision makers. Cadets will spend several lessons in a computer lab environment.
   b. ***Prerequisites or co-requisites***
      None.
   c. ***Required, elective, or selected elective***
      Selected elective

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Apply system dynamics methodology to the solution of large scale, complex problems.
      ii. Create models of dynamic systems, operations and processes.
      iii. Apply system dynamics modeling techniques to simulate behavior over time of systems, operations, and processes.
      iv. Develop policies and controls to improve systems, operations, and processes.
      v. Interpret the output from continuous time simulations of system dynamics models as an aid for decision making.

vi. Prepare and present the results of system dynamics analysis in oral and written form.
vii. Recognize the ethical considerations involved with gathering and analyzing data, using quantitative models, validating assumptions, and reporting results.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	2
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	3
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	5
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***
   - System dynamics modeling methodologies; specifically, causal loop diagrams and stock and flow models.
   - Basic behavior of dynamic systems.
   - Development and communication of a dynamic hypothesis.
   - Model testing and policy analysis.

1. ***Course number and name***
   XE475, Mechatronics

2. ***Credit and contact hours***
   3.5 credit hours (0.0 BS, 3.5 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.5 Sessions/week), LABS: 5 @ 120 min.

3. ***Instructor's or course coordinator's name***
   LTC Joseph L. Heyman, Ph. D.

4. ***Text book, title, author, and year***
   Introduction to Mechatronic Design, 1st edition, by Carryer, Ohline, and Kenny, Prentice Hall, 2011.
   a. ***Other supplemental materials***
      Beginning C for Arduino: Learn C Programming for the Arduino, 2nd Edition, by Jack Purdum, Apress, 2015.
      Fuzzy Control and Identification, by John H. Lilly, John Wiley & Sons, 2010

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      XE 475 is a comprehensive introductory course in the field of mechatronics. Mechatronics is the crossroads in engineering where mechanical engineering, electrical engineering, computer science, and controls engineering meet to create new and exciting real-world systems. Knowledge of mechanical and electrical components, controls theory, and design are integrated to solve actual physical design applications.
   b. ***Prerequisites or co-requisites***
      Co-requisite: XE472 (Dynamic Modeling and Control)
   c. ***Required, elective, or selected elective***
      Selected elective

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Fundamentals: Demonstrate integrated approach to problem solving using both mechanical and electrical engineering skills.
      ii. Sensors and Actuators: Select and implement sensors and actuators to satisfy the performance requirements of a specified task and explain the role of sensors in measurement systems.
      iii. Modeling: Develop mathematical models that represent the governing physics principles of electromechanical systems. Use computer models to predict the behavior of engineered systems. Compare predicted behavior to measured behavior.
      iv. Design, Build, and Test: Design and build a microprocessor-based or circuit-based mechanical system.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	3
3. an ability to communicate effectively with a range of audiences	4
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	1
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	5
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	5
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

- Arduino language programming
- Hardware interrupts
- Microcontroller timer systems and pulse width modulation
- Analog-to-Digital Conversion, Digital-to-Analog Conversion
- Sensors and data acquisition
- Actuators
- System modeling
- Automatic control (PID,Fuzzy)
- Top-down design

1. ***Course number and name***
   CH101, General Chemistry I

2. ***Credit and contact hours***
   4.0 credit hours (ET=0.0 credit hours); LESSONS: 30 @ 75 min (2.5 Att/wk), LABS: 8 @ 120 min.

3. ***Instructor's or course coordinator's name***
   Lt Col Eric D. Mowles

4. ***Text book, title, author, and year***
   Tro, N.J. (2018). *Chemistry: Structure and Properties* (2nd Ed.). Hoboken, NJ: Pearson.
   a. Other supplemental materials
   - *Documentation of Academic Work* by the Office of the Dean. West Point, New York: United States Military Academy, 2017.
   - Science Laboratory Analysis Manual (SLAM), AY 18-1.
   - Military Applications of Chemistry Chapter 1 (18 July 2011)

5. ***Specific course information***
   a. Brief description of the content of the course (catalog description)
   SCOPE: This course provides a solid background in chemistry principles and applications. It includes a study of the nature of matter, its atomic and molecular structure, and associated energies. Fundamental concepts, principles, theories, and laws of chemistry are emphasized. Stoichiometry, states of matter, solutions, foundational thermodynamics, acid-base and redox reactions are addressed. The course also provides the student with an introduction to materials chemistry, environmental chemistry, and military chemistry. An extensive laboratory program is integrated within this course and is designed to develop an appreciation of classical and modern investigative techniques and to reinforce fundamental concepts introduced in the classroom.
   b. Prerequisites or co-requisites
   None
   c. Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program
   Required

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   - Explain and apply foundational chemistry concepts: atomic structure, structure and bonding, states of matter, stoichiometry, chemical reactions, thermodynamics, and chemical explosives
   - Demonstrate scientific knowledge/skills to deduce, predict, and explain observations
   - Develop practices for learning independently

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*
0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	2
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	0
3. Communicate effectively with a range of audiences.	0
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	0
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	1
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	2
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	2
8. Understand the chemical engineering curriculum, including: Chemistry. Also, with weak contributions to material and energy balances; safety and environmental factors; thermodynamics of physical and chemical equilibria; heat, mass, and momentum transfer; chemical reaction engineering; continuous and staged separation processes; process dynamics and control; modern experimental and computing techniques; and process design.	2

7. ***Brief list of topics to be covered***
- Basic tools of chemistry
- Stoichiometry of chemical reactions
- Ideal gases
- Thermodynamics
- Structure and bonding
- Intermolecular forces and states of matter

1. ***Course number and name***
   CH102, General Chemistry II

2. ***Credit and contact hours***
   4.0 credit hours (ET=0.0 credit hours); LESSONS: 30 @ 75 min (2.5 Att/wk),
   LABS: 10 @ 120 min.

3. ***Instructor's or course coordinator's name***
   LTC Chi K. Nguyen

4. ***Text book, title, author, and year***
   Tro, N.J. (2018). *Chemistry: Structure and Properties* (2nd Ed.). Hoboken, NJ: Pearson.
   a. Other supplemental materials
   - *Documentation of Academic Work* by the Office of the Dean. West Point, New York: United States Military Academy, 2017.
   - Science Laboratory Analysis Manual (SLAM), AY 18-1.
   - Military Applications of Chemistry Chapter 1 (18 July 2011)

5. ***Specific course information***
   a. Brief description of the content of the course (catalog description)
   This course is a continuation of CH101. SCOPE This course extends the foundational disciplinary content and practices from General Chemistry I into chemical equilibrium acid/base chemistry, electrochemistry, thermodynamics (entropy and free energy) and kinetics. Basic principles governing organic chemistry is also addressed. The laboratory is integrated within the course. The initial labs develop skills which are they applied to an authentic research problem.
   b. Prerequisites or co-requisites
   CH101 of CH151
   c. Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program
   Required

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   - Cadets explain and apply foundational chemistry concepts.
   - Cadets develop practices for thinking scientifically by deducing, predicting, and explaining scientific observations.
   - Cadets develop practices for learning independently (intellectual self-reliance).
   - Cadets develop effective scientific communication skills.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***

0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	2
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	0
3. Communicate effectively with a range of audiences.	2
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	1
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	2
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	2
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	3
8. Understand the chemical engineering curriculum, including: Chemistry; material and energy balances; safety and environmental factors; thermodynamics of physical and chemical equilibria; heat, mass, and momentum transfer; chemical reaction engineering; continuous and staged separation processes; process dynamics and control; modern experimental and computing techniques; and process design.	2

7. ***Brief list of topics to be covered***
   - Chemical Equilibrium
   - Acid / Base Chemistry
   - Electrochemistry
   - Thermodynamics (entropy and free energy)
   - Kinetics

1. ***Course number and name***
   CH151, Advanced General Chemistry I

2. ***Credit and contact hours***
   4.0 credit hours (ET=0.0 credit hours); LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 8 @ 120 min.

3. ***Instructor's or course coordinator's name***
   LTC Daniel Bahaghighat

4. ***Text book, title, author, and year***
   Tro, N.J. (2018). *Chemistry: Structure and Properties* (2nd Ed.). Hoboken, NJ: Pearson.
   a. Other supplemental materials
   - *Documentation of Academic Work* by the Office of the Dean. West Point, New York: United States Military Academy, 2017.
   - Science Laboratory Analysis Manual (SLAM), AY 18-1.
   - Military Applications of Chemistry Chapter 1 (18 July 2011)
   - Kegley, S.E., D. Landfear, D. Jenkins, and K. Shomglin (2004). *Water Treatment: How Can We Make Our Water Safe to Drink?* New York: W.W. Horton and Company.

5. ***Specific course information***
   a. Brief description of the content of the course (catalog description)
   SCOPE: An advanced coverage of the concepts and principles covered in CH101, including a more in-depth laboratory program. CH101 and 151 provide a solid background in chemistry principles and applications. It includes a study of the nature of matter, its atomic and molecular structure, and associated energies. Fundamental concepts, principles, theories, and laws of chemistry are emphasized. Stoichiometry, states of matter, solutions, foundational thermodynamics, acid-base and redox reactions are addressed. The course also provides the student with an introduction to materials chemistry, environmental chemistry, and military chemistry. An extensive laboratory program is integrated within this course and is designed to develop an appreciation of classical and modern investigative techniques and to reinforce fundamental concepts introduced in the classroom.
   b. Prerequisites or co-requisites
   None
   c. Indicate whether a required, elective, or selected elective (as per Table 5-1) course in the program
   Required

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   - Explain and apply foundational chemistry concepts: atomic structure, structure and bonding, states of matter, stoichiometry, chemical reactions, thermodynamics, and chemical explosives
   - Demonstrate scientific knowledge/skills to deduce, predict, and explain observations
   - Develop practices for learning independently

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***
0 – No contribution; 1 – Weak contribution; 2 – Strong to medium contribution; 3 – Strong contribution.

Student Outcomes Addressed by the Course	Level
1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	2
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	0
3. Communicate effectively with a range of audiences.	0
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	0
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	1
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	2
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	2
8. Understand the chemical engineering curriculum, including: Chemistry. Also, with weak contributions to material and energy balances; safety and environmental factors; thermodynamics of physical and chemical equilibria; heat, mass, and momentum transfer; chemical reaction engineering; continuous and staged separation processes; process dynamics and control; modern experimental and computing techniques; and process design.	2

7. ***Brief list of topics to be covered***
   - Basic tools of chemistry
   - Stoichiometry of chemical reactions
   - Ideal gases
   - Thermodynamics
   - Structure and bonding
   - Intermolecular forces and states of matter

1. ***Course number and name***
   PH205, Physics I

2. ***Credit and contact hours***
   4.0 credit hours (4.0 BS, 0.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 9 @ 75 min.

3. ***Instructor's or course coordinator's name***
   MAJ Cathleen Barker

4. ***Text book, title, author, and year***
   Ling, Sanny, and Moebs, 2016, *University Physics Volumes 1-3*, OpenStax.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      SCOPE: This required, calculus-based core physics course consists of an introduction to nuclear physics, a detailed study of classical mechanics, and an introduction to electricity and magnetism. The course is designed to promote scientific literacy and to develop the use of the scientific method to solve problems. Specific topics include: mass-energy relationship, radioactive decay, radiation attenuation, an introduction to nuclear reactors, and an introduction to nuclear weapons; a detailed study of the laws of motion to include kinematics (translational and rotational), relativity, conservation of energy, conservation of momentum, and mechanical waves; and an introduction to electrostatics and magnetism. An integrated laboratory program illustrates basic scientific techniques and serves to stimulate intellectual curiosity through discovery laboratories. The core physics program is designed to demonstrate the relevance of physics to military technology and to help prepare future Army leaders to anticipate and adapt to technological change.
   b. ***Prerequisites or co-requisites***
      Co-requisites: MA104 (Calculus I)
   c. ***Required, elective, or selected elective***
      Required

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Comprehend physical concepts relevant to follow-on disciplines and future service as an officer.
      ii. Apply physical principles and mathematical competencies with logical processes.
      iii. Analyze and solve problems of increasing complexity.
      iv. Develop the ability to learn independently.
      v. Examine physical phenomena, analyze the data, and communicate the results.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	2
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***

- Newton’s Laws: forces, torques, mass, inertia, acceleration, angular acceleration, friction, drag, uniform circular motion
- Conservation of Energy: kinetic energy, gravitational potential, spring potential energy, work.
- Conservation of Momentum: linear momentum, impulse, angular momentum
- Electricity and Magnetism: electric fields, coulombic force, electric potential, magnetic field, magnetic force, magnetic dipole moment, magnetic torque
- Nuclear Science: energy from the nucleus, radioactive decay, fission reactions, chain reactions
- Lab Program: uncertainty in measurements, linearization, experimental process

1. ***Course number and name***
   PH255, Advanced Physics I

2. ***Credit and contact hours***
   4.0 credit hours (4.0 BS, 0.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 9 @ 75 min.

3. ***Instructor's or course coordinator's name***
   CPT(P) Logan Phillips

4. ***Text book, title, author, and year***
   Ling, Sanny, and Moebs, 2016, *University Physics Volumes 1-3*, OpenStax.

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This required, calculus-based core physics course consists of an introduction to nuclear physics, a detailed study of classical mechanics, and an introduction to electricity and magnetism. The course is designed to promote scientific literacy and to develop the use of the scientific method to solve problems. Specific topics include: mass-energy relationship, radioactive decay, radiation attenuation, an introduction to nuclear reactors, and an introduction to nuclear weapons; a detailed study of the laws of motion to include kinematics (translational and rotational), relativity, conservation of energy, conservation of momentum, and mechanical waves; and an introduction to electrostatics and magnetism. An integrated laboratory program illustrates basic scientific techniques and serves to stimulate intellectual curiosity through discovery laboratories. The core physics program is designed to demonstrate the relevance of physics to military technology and to help prepare future Army leaders to anticipate and adapt to technological change.
   b. Prerequisites or co-requisites
   Co-requisites: MA104 (Calculus I)
   c. Required, elective, or selected elective
   Required

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Comprehend physical concepts relevant to follow-on disciplines and future service as an officer.
   ii. Apply physical principles and mathematical competencies with logical processes.
   iii. Analyze and solve problems of increasing complexity.
   iv. Develop the ability to learn independently.
   v. Examine physical phenomena, analyze the data, and communicate the results.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	2
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***
   - Newton’s Laws: forces, torques, mass, inertia, acceleration, angular acceleration, friction, drag, uniform circular motion
   - Conservation of Energy: kinetic energy, gravitational potential, spring potential energy, work.
   - Conservation of Momentum: linear momentum, impulse, angular momentum
   - Electricity and Magnetism: electric fields, coulombic force, electric potential, magnetic field, magnetic force, magnetic dipole moment, magnetic torque
   - Nuclear Science: energy from the nucleus, radioactive decay, fission reactions, chain reactions
   - Special Relativity: time dilation, length contraction
   - Lab Program: uncertainty in measurements, linearization, experimental process

1. ***Course number and name***
   PH206, Physics II

2. ***Credit and contact hours***
   4.0 credit hours (4.0 BS, 0.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 9 @ 75 min.

3. ***Instructor's or course coordinator's name***
   Dr. David Hutchinson

4. ***Text book, title, author, and year***
   University Physics; Ling, Sanny, and Moebs; 2017; OpenStax

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This calculus-based, core physics course consists of a detailed study of rotating rigid bodies, fluid mechanics, electrostatics and magnetism, direct and alternating current circuits, electromagnetic waves, the wave and particle natures of light. The course is designed to promote scientific literacy and to develop the use of the scientific method to solve problems. An integrated laboratory program illustrates more advanced scientific techniques and serves to stimulate intellectual curiosity through discovery laboratories. This course features an introduction of new material and "depth" reinforcement of select PH205 concepts relevant to continued engineering education through a rigorous theoretical and mathematical curriculum.
   b. Prerequisites or co-requisites
   Pre-requisites: PH205 (Physics I) or PH255 (Advanced Physics I)
   c. Required, elective, or selected elective
   Required

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   1. Comprehend physical concepts relevant to follow-on disciplines and future service as an officer.
   2. Apply physical principles and mathematical competencies with logical processes.
   3. Analyze and solve problems of increasing complexity.
   4. Develop the ability to learn independently.
   5. Examine physical phenomena, analyze the data and communicate the results.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	2
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***

- Block 1: Applied electricity, DC circuits, RC circuits, applied magnetism, Faraday’s law, LC circuits, RLC circuits, transformers
- Block 2: Mechanical waves, wave interference, sound, Doppler shift, electromagnetic waves, reflection and refraction, polarization, mirrors and lenses, thin film interference, diffraction, double slit interference
- Block 3: Hydrostatics, hydrodynamics
- Block 4: Blackbody radiation, photon interaction with matter, introduction to quantum mechanics, lasers

1. ***Course number and name***
   PH256, Advanced Physics II

2. ***Credit and contact hours***
   4.0 credit hours (4.0 BS, 0.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 9 @ 75 min.

3. ***Instructor's or course coordinator's name***
   MAJ Andrew Wilhelm

4. ***Text book, title, author, and year***
   University Physics; Ling, Sanny, and Moebs; 2017; OpenStax

5. ***Specific course information***
   - ***a. Brief description of the content of the course***
     SCOPE: Advanced Physics II offers an in-depth coverage of the concepts and principles covered in PH206 through a more rigorous theoretical and mathematical approach. The course features a robust laboratory program, including advanced laboratory techniques and comprehensive characterization and propagation of uncertainties.
   - ***b. Prerequisites or co-requisites***
     Pre-requisites: PH205 (Physics I) or PH255 (Advanced Physics I)
   - ***c. Required, elective, or selected elective***
     Required

6. ***Specific goals for the course***
   - ***a. Specific outcomes of instruction.***
     - i. Comprehend physical concepts relevant to follow-on disciplines and future service as an officer.
     - ii. Apply physical principles and mathematical competencies with logical processes.
     - iii. Analyze and solve problems of increasing complexity.
     - iv. Develop the ability to learn independently.
     - v. Examine physical phenomena, analyze the data and communicate the results.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	2
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***
   - Block 1: Applied electricity, DC circuits, RC circuits, applied magnetism, Faraday's law, LC circuits, RLC circuits, transformers
   - Block 2: Mechanical waves, wave interference, sound, Doppler shift, electromagnetic waves, reflection and refraction, polarization, mirrors and lenses, thin film interference, diffraction, double slit interference
   - Block 3: Hydrostatics, hydrodynamics
   - Block 4: Blackbody radiation, photon interaction with matter, introduction to quantum mechanics, lasers

1. ***Course number and name***
   MA 103, Mathematical Modeling and Introduction to Calculus

2. ***Credit and contact hours***
   4.5 credit hours (MA=4.5 credit hours);
   LESSONS: 56 @ 55 min (4.0 Sessions/week), LABS: 8 @ 55 min.

3. ***Instructor's or course coordinator's name***
   LTC Kristin Arney

4. ***Text book, title, author, and year***
   Modeling in a Real and Complex World, United States Military Academy at West Point, 2019.
   Calculus: Early Transcendentals 8th Edition. James Stewart. Cengage Learning. 2015.

5. ***Specific course information***
   a. Brief description of the content of the course
   MA103 is the first course of the mathematics core curriculum. It emphasizes applied mathematics through modeling. Students develop effective strategies to solve complex and often ill-defined problems. The course exercises a wide array of mathematical concepts while nurturing creativity, critical thinking, and learning through activities performed in disciplinary and interdisciplinary settings. The course introduces calculus using continuous and discrete mathematics while analyzing dynamic change in applied problems. Students employ a variety of technological tools to enhance the ability to visualize concepts, to explore ideas through experimentation and iteration, to complete complex and time-consuming computations, and to develop numerical, graphical, and analytical solutions that enhance understanding.
   b. Prerequisites or co-requisites
   None
   c. Required, elective, or selected elective
   Required

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Construct models using discrete systems and difference equations to solve problems involving dynamic change.
   ii. Construct models using continuous equations to explain and analyze data.
   iii. Use matrix algebra to solve systems of equations.
   iv. Use discrete and continuous models to develop forecasts and make predictions.
   v. Explain the concepts of limits, average rates of change, and instantaneous rates of change, and use these concepts to describe the long-term behavior of mathematical models.
   vi. Use technology, especially when developing and using math models, to visualize concepts, to explore potential solutions, and to execute complex and time-consuming computations when solving applied problems.
   vii. Interpret results of math models to explain conclusions about the underlying problems.
   viii. Identify the assumptions required to construct a math model of a given applied problem and justify the reasonableness and necessity of those assumptions.

ix. Apply concepts from discrete math, matrix algebra, and calculus to model and solve complex and interdisciplinary problems.
x. Use a mathematics textbook, via independent reading and study, to learn, examine and explain mathematical concepts.
xi. Explain assumptions, models, and results using technical language in written and oral presentation formats that demonstrate effective communication in terms of substance, organization, style, and correctness.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	3
3. an ability to communicate effectively with a range of audiences	2
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	3
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***

– Modeling with 1st order linear Discrete Dynamical Systems
– Introduction to vector and matrix algebra
– Modeling with systems of linear equations
– Modeling with 1st order multi-variate linear Discrete Dynamical Systems
– Modeling with continuous functions: Linear, Power, Exponential and Trigonometric
– Introduction to Calculus: Rates of Change and Parametric Equations

1. ***Course number and name***
   MA153, Math Modeling and Introduction to Differential Equations

2. ***Credit and contact hours***
   4.5 credit hours (0.0 BS, 0.0 ET, 4.5 MA)
   LESSONS: 56 @ 55 min (4.0 Sessions/week), LABS: 8 @ 55 min.

3. ***Instructor's or course coordinator's name***
   LTC Stanley Florkowski

4. ***Text book, title, author, and year***
   Zill, D.G., 2017, *Differential Equations with Boundary-Value Problems, Ninth Edition*.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      SCOPE: This is the first course of a two-semester advanced mathematics sequence for selected cadets who have validated single variable calculus and demonstrated strength in the mathematical sciences. It is designed to provide a foundation for the continued study of mathematics, sciences, and engineering. This course emphasizes the interaction between mathematics and the physical sciences through modeling with differential equations. Topics may include a study of first order differential equations, second order linear equations, systems of first order linear and non-linear equations, numerical methods, and non-linear equations and stability. An understanding of course material is enhanced through the use of a computer algebra system.
   b. ***Prerequisites or co-requisites***
      Pre-requisites: None
   c. ***Required, elective, or selected elective***
      Required

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Students understand and can apply analytical, numerical and qualitative methods to solve first and second order ordinary differential equations (ODEs).
      ii. Students understand and can apply analytical, numerical and qualitative methods to solve systems of linear and nonlinear first order ODEs.
      iii. Students improve the quality of their written and verbal communication of mathematics through in-class board presentations, course homework assignments, technology labs, application day exercises and the course projects.
      iv. Leverage technology to visualize concepts, graphically and analytically explore solutions to ODE models and numerically approximate solutions to complex ODEs.
      v. Build critical thinking skills by integrating in class problems, technology labs, application day exercises and the course project.
      vi. Develop knowledge, curiosity and appreciation for the application of mathematics in multiple disciplines.
      vii. Students can design, solve and interpret the results of mathematical models using ODEs to address complex and interdisciplinary problems.
      viii. Students learn good scholarly habits for progressive intellectual development.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	1
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	1
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	2
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

- Math Modeling: differential equations as math models, linear and nonlinear models, modeling with systems, model evaluation, course modeling project
- First Order Differential Equations: solution curves, vector fields, and autonomous differential equations, separable equations, integrating factor, Euler’s method
- Higher Order Differential Equations: reduction of order, method of characteristic equations, method of undetermined coefficients, power series solutions
- Systems of Linear Differential Equations: eigenvalue decomposition, autonomous systems, linearization and local
- The Laplace Transform: Laplace transform, inverse transform and transform or derivatives, step function, Dirac delta function
- Technology: technology labs using Mathematical and Excel, course project

1. ***Course number and name***
   MA104, Calculus I

2. ***Credit and contact hours***
   4.5 credit hours (0.0 BS, 0.0 ET, 4.5 MA)
   LESSONS: 56 @ 55 min (4.0 Sessions/week), LABS: 8 @ 55 min.

3. ***Instructor's or course coordinator's name***
   COL Matt Rogers

4. ***Text book, title, author, and year***
   Stewart, J., 2015, *Calculus: Early Transcendentals (Eighth Edition)*, Cengage Learning.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      SCOPE: This is the second semester of the mathematics core curriculum. It provides a foundation for the continued study of mathematics and for the subsequent study of the physical sciences, the social sciences, and engineering. MA104 covers topics in single variable differential and integral calculus, parametric equations, 3-dimensional geometry, and vectors. Throughout the course, mathematical models motivate the study of topics such as optimization, accumulation, change in one variable, motion in space, and other topics from the natural, social, and decision sciences. An understanding of course material is enhanced through the use of computer algebra systems.
   b. ***Prerequisites or co-requisites***
      Pre-requisites: MA103 (Math Modeling/Introduction to Calculus)
   c. ***Required, elective, or selected elective***
      Required

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Internalize the concept of the derivative as a rate of change, the integral as the accumulation of change and that these two concepts are inversely related by the fundamental theorem of calculus.
      ii. Understand when and how to apply differential and integral calculus to solve single-variable problems involving changing quantities.
      iii. Interpret and communicate solution methodology and results through the use of the United States Military Academy Mathematical Problem-Solving Process.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	4
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	3
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***

- Derivative Concepts: Mathematical functions, limits and continuity, rates of change, derivative rules, implicit differentiation, maximum and minimum theorems
- Derivative Applications: Related rates, natural sciences, optimization
- Integral Concepts: Riemann Sums, Basic Antiderivatives/Indefinite Integrals, Definite Integrals, Fundamental Theorem of Calculus, Integration Techniques (substitution, integration-by-parts)
- Integral Applications: Net change theorem, area between curves, solids of revolution, work, probability density functions
- Projectile Motion: parametric equations, vector derivation of motion in space
- Projects: Three projects that allow students to apply concepts of calculus applications to solve problems related to a real Army scenario

1. ***Course number and name***
   MA205, Calculus II

2. ***Credit and contact hours***
   4.0 credit hours (0.0 BS, 0.0 ET, 4.0 MA)
   LESSONS: 40 @ 75 min (2.5 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   LTC Lee Evans

4. ***Text book, title, author, and year***
   Stewart, J., 2016, *Calculus: Early Transcendentals, Eighth Edition*.

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This course provides a foundation for the continued study of mathematics and for the subsequent study of the physical sciences, social sciences, and engineering. MA205 covers topics in multivariable differential and integral calculus, differential equations, and infinite series representations of functions. Throughout the course mathematical models motivate the study of topics such as optimization, accumulation, change in several variables, differential equations, and other topics from the natural, social, and decision sciences. An understanding of course material is enhanced through the use of computer algebra systems.
   b. Prerequisites or co-requisites
   Pre-requisites: MA104 (Calculus I)
   c. Required, elective, or selected elective
   Required

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Acquire a body of knowledge to support the rigorous course work in science, technology, engineering, and mathematics (STEM) disciplines.
   ii. Leverage technology by using Mathematica/MATLAB to enhance your capability to visualize, solve, analyze, and experiment with a myriad of mathematical functions and models.
   iii. Improve communication skills both verbally and in writing by describing thought process in solving mathematics problems.
   iv. Build confident and competent problem solvers through in-class experiences, homework exercises, and projects that analyze real world problems, make critical assumptions, model the problem, solve the problem, and then interpret your results.
   v. Develop habits of mind for time management, creativity, work ethic, thinking interdependently, critical thinking, lifelong learning, and curiosity.
   vi. Foster interdisciplinary perspective.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	1
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	1
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	2
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***

- Multivariable Differentiation: partial derivatives, tangent planes, linear approximation, MV chain rule, gradient, directional derivatives, MV maximization/minimization, MV optimization, Lagrange multipliers
- Multivariable Integration: volume estimation, iterated integrals, general regions, polar regions, center of mass, MV probability, triple integrals, cylindrical and spherical coordinates
- Infinite Sequences and Series: convergence testing, power series, Taylor series
- Ordinary Differential Equations: slope fields, Euler’s method, separation of variables, integrating factor, method of characteristic equations, systems of ODEs
- Applications: population growth, Newton’s heating/cooling, mixing, spring-mass systems, predator-prey
- Technology: MATLAB programming assignment, course project

1. ***Course number and name***
   MA255, Advanced Multivariable Calculus

2. ***Credit and contact hours***
   4.5 credit hours (0.0 BS, 0.0 ET, 4.5 MA)
   LESSONS: 56 @ 55 min (4.0 Sessions/week), LABS: 8 @ 55 min.

3. ***Instructor's or course coordinator's name***
   LTC Stanley Florkowski

4. ***Text book, title, author, and year***
   Stewart, J., 2016, *Calculus – Early Transcendentals 8th edition*.

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This is the second course of a two-semester advanced mathematics sequence for selected cadets who have validated single variable calculus and demonstrated strength in the mathematical sciences. It is designed to provide a foundation for the continued study of mathematics, sciences, and engineering. This course consists of an advanced coverage of topics in multivariable calculus. Topics may include a study of infinite sequences and series, vectors and the geometry of space, vector functions, partial derivatives, multiple integrals, and vector calculus. An understanding of course material is enhanced through the use of a computer algebra system.
   b. Prerequisites or co-requisites
   Pre-requisites: MA153 (Math Modeling/Introduction to Differential Equations)
   c. Required, elective, or selected elective
   Required

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Students can use vectors and vector functions to model motion and surfaces in three-dimensional space.
   ii. Students understand the concepts of multivariable differential calculus and can apply it to solve unconstrained and constrained optimization problems.
   iii. Students understand the concepts of multivariable integral calculus and can apply it solve problems involving accumulation.
   iv. Students understand and apply the concepts of vector calculus.

b. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course*

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	1
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	3
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	3
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***

– Principles: Vectors and the geometry of space, partial derivatives of multivariable functions, multiple integrals, 3D coordinate systems (cartesian, cylindrical, spherical), line integrals, Green's Theorem, Stoke's Theorem, Divergence Theorem

– Technologies: Mathematica.

– Project: Interdisciplinary project requiring students to research and apply mathematical principles learned in MA255 to different STEM disciplines.

1. ***Course number and name***
   MA206, Probability and Statistics

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 0.0 ET, 3.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   LTC Kevin Cummiskey

4. ***Text book, title, author, and year***
   Jay L. Devore, 9th Edition, Probability and Statistics for Engineering and the Sciences, Cengage Learning.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      SCOPE: This is the final course in the mathematics core curriculum. The course develops cadet ability to structure their reasoning under conditions of uncertainty and presents fundamental probability and statistical concepts that support the USMA core curriculum. Coverage includes data analysis, probabilistic models, independence, simulation, random variables and their distributions, hypothesis testing, confidence intervals, and linear regression. The course also introduces engineering applications of probability and statistics techniques. Applied problems motivate concepts, and technology enhances understanding, problem solving, and communication.
   b. ***Prerequisites or co-requisites***
      MA104 or MA255
   c. ***Required, elective, or selected elective***
      Required

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Apply the axioms, theorems, and basic properties of probability to quantify the likelihood of events.
      ii. Use discrete and continuous random variables to model phenomena and answer basic probability
      iii. Produce and interpret graphical displays and numerical summaries of data.
      iv. Understand and use basic ideas of statistical inference (hypothesis tests and confidence intervals) in a variety of settings.
      v. Employ linear regression models in the context of statistical analysis; interpret and draw conclusions from the standard output of statistical software packages.
      vi. Communicate results of statistical analyses to general audiences.
      vii. Apply probability and statistics concepts to a variety of engineering topics.

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	5
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	3
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***
– Data Analysis
– Probability Theory – Properties, Axioms, Sample Space, and Random Variables
– Counting Techniques, Conditional Probability, and Independence
– Unnamed Discrete and Continuous Distributions
– Named Discrete and Continuous Distributions
– Central Limit Theorem
– Confidence Intervals
– Hypothesis Testing
– Simple and Multiple Regression

1. ***Course number and name***
   MA256, Advanced Probability and Statistics

2. ***Credit and contact hours***
   3.0 (BS=0.0, ET=0.0, MA=3.0)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   LTC Charles A. Sulewski

4. ***Text book, title, author, and year***
   Probability and Statistics for Engineering and the Sciences 9th Edition, Jay L. Devore, 2016.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      This is the advanced version of the final course in the mathematics core curriculum. The course develops cadet ability to structure their reasoning under conditions of uncertainty and presents fundamental probability and statistical concepts that support the USMA core curriculum. Coverage includes data analysis, probabilistic models, independence, simulation, random variables (including jointly distributed random variables) and their distributions, hypothesis testing, confidence intervals, linear regression and analysis of categorical data. Emphasis will be on model based approaches and significant time will be spent on selecting an appropriate model and assessing its validity. Applied problems illustrate concepts, and technology enhances understanding, problem solving, and communication.
   b. ***Prerequisites or co-requisites***
      Pre-requisites: MA205 Calculus II, or MA255, Advanced Multivariable Calculus
   c. ***Required, elective, or selected elective***
      Required

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Understand the notion of randomness and the role of variability and sampling in making inferences.
      ii. Apply the axioms, theorems, and basic properties of probability and conditional probability to quantify and communicate the likelihood of events.
      iii. Employ univariate and joint models using discrete or continuous random variables to answer basic probability questions.
      iv. Employ the concepts of confidence intervals and know when they apply to gain insight into populations from their representative samples.
      v. Construct several types of hypothesis tests and develop appropriate conclusions.
      vi. Construct, apply, assess, and communicate linear regression models to estimate and interpret regression coefficients and draw conclusions from the models.
      vii. Model, solve, and interpret solutions to applied problems that can be examined using principles of probability theory, simulation, or statistical analysis.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	3
3. an ability to communicate effectively with a range of audiences	4
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	3
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	4
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	4
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	4

7. ***Brief list of topics to be covered***
   - Display, analyze, and interpret data.
   - Calculate measures of location and variability and discuss the importance of each.
   - Describe events, the union of events, the intersection of events, the complement of events, or any combination thereof with appropriate notation.
   - Calculate and interpret probabilities, expected values, and variances for discrete and continuous random variables.
   - Using data analytic techniques, explore data to gain insight about relationships between factors.
   - Calculate confidence intervals, confidence bounds, and prediction intervals about specified population parameters; interpret the results in the context of the specified scenario or problem.
   - Perform and evaluate hypothesis tests using a p-value; interpret the results in the context of the specified scenario or problem.
   - Develop and assess multiple regression models with continuous and categorical variables.

1. ***Course number and name***
   IT105, Introduction to Computing and Information Technology

2. ***Credit and contact hours***
   3.0 credit hours (0.0 BS, 2.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   COL Tanya T. Estes

4. ***Text book, title, author, and year***
   Understanding the Digital World What You Need to Know about Computers, the Internet, Privacy, and Security, by Brian W. Kernighan, Princeton University Press, New Jersey, 2017.

5. ***Specific course information***
   a. Brief description of the content of the course
   SCOPE: This course provides an introduction to the fundamentals of computing and Cyberspace. The course presents basic program design and construction techniques, with consideration given to principles of software engineering. Problem solving using computing devices as tools is a central theme throughout the course as students employ various design methodologies. Students utilize an integrated development environment and contemporary application software. Emphasis is placed on critical thinking, creativity, and learning how to learn. Students are introduced to legal, ethical, professional, and security issues and the challenges, opportunities, and attributes of the cyber domain.
   b. Prerequisites or co-requisites
   None
   c. Required, elective, or selected elective
   Required

6. ***Specific goals for the course***
   a. Specific outcomes of instruction.
   i. Function as an ethical, secure, and competent user in West Point's immersive technology and cyber environment.
   ii. Apply sequence, selection, iteration, modular design, and file IO using a modern programming language, algorithmic thinking, and a problem-solving process.
   iii. Describe the roles played by the major components of a computer and the implications of those components on the operation of the computer.
   iv. Select IT applications as potential solutions to problems.
   v. Examine legal, ethical, professional, and security issues associated with IT.
   vi. Describe the challenges, opportunities, and attributes of the cyber domain.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course
1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	2
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	2
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	2
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	1
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	1
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***
- Data encoding
- Hardware components
- Simple microcontroller programming and interfacing
- Introduction to operating systems and file systems
- Introduction to programming in Python (selection, sequencing, iteration)
- Introduction to algorithms
- Introduction to network concepts and protocols
- Cyber Domain (threats, ethics, policy, and law)
- Intellectual property in the Cyber Domain

1. ***Course number and name***
   EV203, Physical Geography

2. ***Credit and contact hours***
   3.0 credit hours (2.5 BS, 0.0 ET, 0.0 MA)
   LESSONS: 30 @ 75 min (2.0 Sessions/week), LABS: 0 @ 0 min.

3. ***Instructor's or course coordinator's name***
   LTC Jason Ridgeway

4. ***Text book, title, author, and year***
   Hess D. McKnight's Physical Geography: A landscape appreciation. New York (NY): Pearson Education, Inc.; 2017.
   Rubenstein J. *The cultural landscape: An introduction to human geography*. 12th ed. New York (NY): Pearson Education, Inc.; 2017.

5. ***Specific course information***
   a. ***Brief description of the content of the course***
      SCOPE: This core course provides cadets with a fundamental understanding of scientific principles and processes of earth science, meteorology, climatology, geomorphology and environmental systems. Further, the course introduces cadets to technical skills - (terrain analysis, image interpretation and spectral analysis, remote sensing, global positioning system, geographic information systems cartography) - to delineate the geographic distribution of landforms, weather, climate, and culture systems; and evaluate their potential impact on military operations. Lessons are reinforced by use of practical exercises, terrain walks, and computer exercises to demonstrate the interrelationship between physical and human processes and their impact on the environment. Historical and contemporary vignettes are employed to demonstrate how weather, climate, terrain, soils, vegetation and culture are important, cogent and frequently decisive in military operations.
   b. ***Prerequisites or co-requisites***
      None
   c. ***Required, elective, or selected elective***
      Required

6. ***Specific goals for the course***
   a. ***Specific outcomes of instruction.***
      i. Describe the fundamental concepts of physical geography incorporating earth science, meteorology, climatology, and geomorphology.
      ii. Employ remote sensing, cartography, digital terrain analysis, and geographic information systems to analyze physical and cultural landscapes.
      iii. Discuss the scientific principles of meteorology and the geographic distribution of weather systems, as well as the impact of weather on military operations.
      iv. Demonstrate an understanding of the scientific basis for the geographic distribution of climates and explain the physical processes that determine the climate of a region. Evaluate the links between weather, climate, vegetation, soil regimes, weathering processes, and landforms.

v. Recognize the fundamentals of the geologic structure of the Earth's crust and endogenic and exogenic forces that shape the Earth's surface. Explain the global distribution of landforms in terms of tectonic activity and geomorphic processes.
vi. Understand how cultural systems and landscapes correlate to cultural geography.
vii. Demonstrate an appreciation for the linkages between the physical and human environment, and understand potential impacts on military operations; understand one's life-long responsibility for environmental stewardship

b. ***Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course***

1 – No contribution; 2 – Small contribution; 3 – Average contribution; 4 – Large contribution; 5 – Very large contribution

Student Outcomes Addressed by the Course	Level
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	3
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	2
3. an ability to communicate effectively with a range of audiences	2
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	3
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	3
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	2
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	3

7. ***Brief list of topics to be covered***

- Earth-Sun Relations
- Basic understanding of the atmosphere and heat transfer mechanisms throughout the Earths energy budget
- Principles of global circulation to include weather and climate
- Fundamentals of geomorphology
- Basic recognition of specific landforms in various landscapes. The processes which created these landforms
- Introduction to culture

Appendix B – Faculty Resumes

Faculty Supporting the Chemical Engineering Program

Department of Chemistry and Life Science	Page
Matthew Armstrong	B-3
Andrew Biaglow	B-5
Geoffrey Bull	B-7
F. John Burpo	B-9
Jeff Chin	B-11
Trevor Corrigan	B-13
Samuel Cowart	B-15
Corey James	B-17
Eileen Kowalski	B-19
April Miller	B-21
Enoch Nagelli	B-23
Kamil Woronowicz	B-25
Caspar Yi	B-27
Department of Electrical Engineering and Computer Science	
Jack Cooperman	B-29
Duncan	B-30
Steven Elgan	B-31
Joshua Groen	B-33
Peter Hanlon	B-35
Joseph Heyman	B-37
James Raftery	B-39
Department of Civil and Mechanical Engineering	
Civil Engineering Program	
Claude Barron	B-41
Brad Davis	B-43
Mark Evans	B-44
David Flaherty	B-46
Linford	B-48
Brad McCoy	B-49
Kevin McMullen	B-51
John Pegues	B-53
Rahul Verma	B-54
Brad Wambeke	B-56
Rebecca Zifchock	B-58
Department of Civil and Mechanical Engineering	
Mechanical Engineering Program	
Ozer Arnas	B-60
Andrew Bellochio	B-62
Frederick Davidson	B-64
Carolann Koleci	B-66

Richard Melnyk B-68
Matthew Miller B-70
Jeremy Paquin B-72
Gunnar Tamm B-74

Department of Mathematical Sciences
Kristopher Ahlers B-76
Daniel Meadows B-77

Faculty Course Directors in the Core Courses
Kristin Arney, MA103 B-79
Daniel Bahaghighat, CH151 B-81
Cathleen Barker, PH205 B-83
Kevin Cummeski, MA206 B-85
Tanya Estes, IT105 B-87
Lee Evans, MA205 B-89
Stanley Florkowski, MA153, MA255 B-91
David Hutchinson, PH206 B-93
Kathleen LeForte, CH275 B-94
Eric Mowles, CH101 B-96
Chi Nguyen, CH102 B-98
Logan Phillips, PH255 B-100
Jason Ridgeway, EV203 B-102
Matthew Rogers, MA104 B-104
Charles Sulewski, MA256 B-106
Andrew Wilhelm, PH256 B-108

1. Name

Matthew Armstrong — Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

Ph.D., Chemical Engineering, University of Delaware, 2015
M.S., Chemical Engineering, Rensselaer Polytechnic Institute, 2005
B.S., Chemical Engineering, Rensselaer Polytechnic Institute, 1996

3. Academic experience – institution, rank, title, dates, full or part time

USMA, Instructor, 2005-2007
USMA, Assistant Professor, 2007-2008; 2015-2018
USMA, Associate Professor, 2018-

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Military Assignments: (all fulltime)
Chemical Engineering Program Director (2018 -); Assistant Chemical Engineering Program Director (2015-2018); G37, Nuclear/Radiological Training and Exercises, 20th SUPCOM (CBRNE) (2011-2012); Deputy Team Chief, Nuclear Disablement Team 2, 20th SUPCOM (CBRNE) (2010-2011); Characterization Team Leader/Ground Sample Collection Team Leader, Nuclear Disablement Team 2, 20th SUPCOM (CBRNE) (2009-2010); Operations Officer/Future Plans Officer and Operations Officer/ Mentor-Police Mentor Team, Afghanistan Regional Security Integration Command – Central/ Regional Police Advisory Command- Central, Camp Blackhorse/ Camp Dubs, Afghanistan, Operation Enduring Freedom (2008-2009); Assistant Professor & S-4 Department of Chemistry and Life Science, United States Military Academy; Company Commander, Warrior Replacement Company, 2nd Infantry Division, Camp Casey, Republic of Korea; Division Radio Officer, 2nd Infantry Division, Camp Red Cloud, Republic of Korea; Signal Company Executive Officer and Battalion S-4, Supply and Logistics Officer, 82nd Signal Battalion, FT Bragg (1999-2000); Rifle Platoon Leader; Anti-Tank Platoon Leader, 2nd Battalion, 504th Parachute Infantry Regiment, 82nd Airborne Division, FT Bragg (1997-1998).

5. Certifications or professional registrations

Infantry Officer Basic Course qualification; Ranger qualification; Airborne qualification; Signal Captain's Career Course (SCCC) qualification; Fundamentals of Engineering Exam, Delaware, APR08; Intermediate Level Education qualification; Nuclear Infrastructure and Assessment Course; Theater Nuclear Operations Course.

6. Current membership in professional organization

American Institute of Chemical Engineers (AIChE)
Society of Rheology (SOR)
Society of Industrial and Applied Math (SIAM)

7. Honors and awards

Academic: Phi Kappa Phi; Tau Beta Pi

Military: Bronze Star Medal, Meritorious Service Medal (3), Army Commendation Medal (3), Army Achievement Medal, National Defense Service Medal, Afghanistan Campaign Medal, Global War on Terror Service Medal, Army Service Medal, Overseas Service Medal (2)

8. Service activities (within and outside of the institution)

Institutional Service: Cadet Sponsorship Program; West Point AIChE Chapter Assistant Officer-in-Charge; Department Academic Counselor; Army Swimming and Diving Team Assistant Officer Representative; Served as Department Budget and Supply Officer.

Professional Service: ABET Committee; Title10 Hiring Committee; Performed duties as referee for 11 peer review journals: Rheologica Acta (5 articles); Journal of Rheology (3 articles); Chemical Engineering Education (2 articles); Journal of Non-Newtonian Fluid Mechanics (1 article).

9. Publications and presentations from the past five years

Matthew Armstrong, Joshua White, Jesse Hudgins, Geoffrey Bull, Corey James, Dawn Riegner, April Miller, Andrew Biaglow, "Developing Chemical Engineering Acumen by Brewing *Kicking Mule Beer*" *Chemical Engineering Education*, Vol. 53, No. 2, Spring2019

Matthew Armstrong, Jeffrey Horner, Michael Clark, Michael Deegan, Timothy Hill, Charles Keith, Lynne Mooradian, "Evaluating Rheological Models for Human Blood Using Steady State, Transient, and Oscillatory Shear Predictions". *Rheo. Acta, 1-24 (2018) DOI: 10.1007/s00397-018-1109-5*

Jeffrey S. Horner, **Matthew J. Armstrong**, Norman J. Wagner, Antony Beris, "Investigation of blood rheology under steady and unidirectional large amplitude oscillatory shear", 62:577 MAR (2018). Journal of Rheology. https://doi.org/10.1122/1.5017623

Michael Clarion, Michael Deegan, Tyler Helton, Jesse Hudgins, Nick Monteferante, Evan Ousley, **Matthew J. Armstrong**, "Contemporary Modeling and Analysis of Steady State and Transient Human Blood Rheology", *Rheologica Acta*, 57(2), 141-168 (2018). https://doi.org/10.1007/s00397-017-1062-8

10. Most recent professional development activities

ABET Committee; Technical Scholarship Committee; Chemical Engineering Program Director

1. Name

Andrew I. Biaglow Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

Doctor of Philosophy, Chemical Engineering, University of Pennsylvania, Philadelphia, Pennsylvania, 1993. Bachelor of Science, Chemical Engineering, Case Western Reserve University, 1988.

3. Academic experience – institution, rank, title, dates, full or part time

Twenty-five years (USMA, Full Time, 1994-present): Professor (2010-present); Associate Professor (1999-2010); Assistant Professor (1994-1999); Chemical Engineering Program Director (2002-2015).

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Consultant, catalyst development, RDECOM, Picatinny Arsenal and Benet Laboratories, 2012-present; Consultant, Simulation Solutions, Inc., 179 Avenue at the Common, Shrewsbury, NJ, 07702, 2006-present; Consultant, catalyst development, Nepera, Inc., Route 17, Harriman, NY 10926, 1996-2006; Consultant, catalyst development, Corporate Research Labs, Exxon Research and Engineering Company, Annandale, NJ 08801, 1998-2004; Consultant, catalyst development, Hoechst Celanese, Inc., Charlotte, NC 28232-6085, 1996-2004.

5. Certifications or professional registrations

None

6. Current membership in professional organization

American Institute of Chemical Engineering, American Society for Engineering Educators, International Zeolite Association

7. Honors and awards

Dean's Award for a Career of Excellent Teaching, 2019, for a career of outstanding teaching and contributions to the development of leaders of character; *Superior Civilian Service Award,* Department of the Army, 2009 and 2015, for contributions to the ABET accreditation efforts; *Certificate of Appreciation for Patriotic Civilian Service,* Department of the Army, 2008, for developing and implementing innovative teaching methods in the general chemistry course; *Commander's Award for Public Service,* Department of the Army, 2005, for outstanding contributions as a member of the Library Working for the Middle States reaccreditation committee; *Commander's Award for Civilian Service,* Department of the Army, 1999, for outstanding contributions to the Outcomes Assessment Working Group for the Middle States reaccreditation committee.

8. Service activities (within and outside of the institution)

Promotions and Credentials Committee (2012-present); ABET Committee (2005-present); Library Committee (1995-present); Language Goal Team (2010-2018); Laboratory Resource Committee (2011-2014); Middle States Accreditation Committee, (1997-1999, 2005-2007.

2017-2019); Engineering and Technology Committee (2002-2005); Organizing Committee for the Mid Atlantic Regional Meeting of the American Society of Engineering Educators, (2001-2002); ABET Program Evaluator, (2010-present); Officer, Mid-Hudson Section of the American Chemical Society (ACS). Member-at-Large (1996-1997), Secretary (1998), Treasurer (1999), Chair Elect (2000), Chair (2001), Past Chair(2002); Organizing Committee, 10th International Zeolite Conference of the International Zeolite Association (IZA), Baltimore, MD, (1996); Numerous PUSMA, Academy Professor and Civilian hiring committees.

9. Publications and presentations from the past five years

"Consistency of Thermodynamic Properties from Process Simulators. I. Comparison of Lee-Kesler Enthalpy, Entropy, and Fugacity. Research complete, manuscript in preparation.

"Design of a Thermoelectric Distillation Column," patent application in preparation.

"Teach Yourself CHEMCAD," textbook, for publication with Wiley, under contract and in preparation.

"Developing Chemical Engineering Acumen by Brewing Kicking Mule Beer," M. Armstrong, J. White, J. Hudgins, G. Bull, C. James, D. Riegner, A. Miller, and **A. Biaglow**, in *Chemical Engineering Education*, Spring 2019, Volume 53, Number 2 (2019), pages 101-111.

"Chemical Engineering Lab for Seniors at the United States Military Academy," C. James, M. Armstrong, **A. Biaglow**, and E. Nagelli, Conference Proceedings, 2018 Annual Meeting of the American Institute of Chemical Engineers, Pittsburgh, PA, October 29 to November 2, 2018 (manuscript also in prep for *Chemical Engineering Education*.)

"Success in Chemical Engineering at USMA as Predicted by CEER Score," T. Corrigan, A. Pfluger, B. Jonas, A. Miller, D. Bahaghighat, E. Mowles, G. Bull, C. James, E. Nagelli, M. Eslinger, M. Armstrong, R. Lachance, and **A. Biaglow**, Research complete, manuscript in preparation for Teaching and Learning the West Point Way and possibly *Chemical Engineering Education*.

"Using the Fundamentals of Engineering Exam to Assess Student Performance in a Chemical Engineering Curriculum," with G. Bull and M. Armstrong, in Fall 2016 ASEE Mid-Atlantic Regional Conference Papers, 21-22 October 2016. https://www.hofstra.edu/academics/colleges/seas/seas-fall16-asee-conference-papers.html

"Assessment of Student Ability to Identify Engineering Problems," with G. Bull and M. Armstrong, in Fall 2016 ASEE Mid-Atlantic Regional Conference Papers, 21-22 October 2016. https://www.hofstra.edu/academics/colleges/seas/seas-fall16-asee-conference-papers.html.

10. Most recent professional development activities

Various publications and presentations; ABET Program Evaluator (PEV) Training, annual ABET evaluation visits to universities since 2010; peer reviews for technical journals.

1. Name

Geoffrey Bull   Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

Ph.D., Nuclear Engineering and Engineering Physics, University of Wisconsin, 2014
M.S., Nuclear Engineering and Engineering Physics, University of Wisconsin, 2005
B.S., Engineering Physics, United States Military Academy, 1996

3. Academic experience – institution, rank, title, dates, full or part time

USMA, Instructor, 2005-2008
USMA, Assistant Professor, 2014-2019
USMA, Associate Professor, 2019-present

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Military Assignments: (all full-time)

Chemical Engineering Program Director (2015 -2018); Assistant Chemical Engineering Program Director (2014-2015); Assistant Team Chief, Nuclear Weapons Effects Team, Defense Intelligence Agency (2008-2011); Battery Commander, Air Defense Artillery Battery, 3rd Armored Cavalry Regiment (2001-2003); Aide-de-Camp, Commander Kosovo Force – 2B (1999-2000); Battery Executive Officer, Headquarters and Headquarters Battery, 4th Battalion, 3rd Air Defense Artillery (1999); Platoon Leader (Bradley Stinger Fighting Vehicle and Early Warning), B Battery and Headquarters and Headquarters Battery, 4th Battalion, 3rd Air Defense Artillery (1997-1999)

5. Certifications or professional registrations

Air Defense Artillery Officer Basic Course qualification; Short-Range Air Defense (SHORAD) Officer qualification; Airborne qualification; Air Assault qualification; Aviation Captain's Career Course (ACCC) qualification; Combined Arms Service and Staff School (CAS3) qualification; Intermediate Level Education qualification; Nuclear Infrastructure and Assessment Course; Theater Nuclear Operations Course; Distinguished Rifleman qualification.

6. Current membership in professional organization

American Institute of Chemical Engineers (AIChE)
American Chemical Society (ACS)
American Society of Engineering Education (ASEE)

7. Honors and awards

Academic: Sigma Pi Sigma

Military: Defense Meritorious Service Medal, Meritorious Service Medal (2), Army Commendation Medal (3), Army Achievement Medal, National Defense Service Medal, Iraqi Campaign Medal, Global War on Terror Service Medal, Army Service Medal, Overseas Service Medal, Kosovo Service Medal, NATO Medal

8. Service activities (within and outside of the institution)

Institutional Service: Cadet Sponsorship Program; Department Academic Counselor; Army Rifle Team Officer Representative; Head Rifle Team Coach Search Committee; Title 10 Assistant Professor Search Committee (2); Rotating Faculty Search Committee (4)

Professional Service: Invited co-chair of the Division of Nuclear Chemistry and Technology technical session at the 2019 American Chemical Society Fall National Meeting (August 2019).

9. Publications and presentations from the past five years

Armstrong, M., White, J., Hudgins, J., **Bull, G.R.**, James, C., Riegner, D., Miller, A., Biaglow, A. "Developing Chemical Engineering Acumen by Brewing Kicking Mule Beer." *Chemical Engineering Education*. Accepted November 29, 2018. Publication date pending.

Bull, G.R., Oakley, J.O., and Corradini, M.L., "Effects of Bubble Injection on Heat Transfer from a Volumetrically Heated Sulfate Salt Solution." *Nuclear Science and Engineering* Published online October 11, 2018. https://doi.org/10.1080/00295639.2018.1514195

Bull, G.R., Armstrong, M.J., and Biaglow, A. "Using the Fundamentals of Engineering Exam to Assess Student Performance in a Chemical Engineering Curriculum." Conference Proceedings. American Society of Engineering Education Mid-Atlantic Regional Conference, October 2016.
http://www.hofstra.edu/academics/colleges/seas/seas-fall16-asee-conference-papers.html

Armstrong, M.J., **Bull, G.R.**, and Biaglow, A. "Assessment of Student Ability to Identify Engineering Problems." Conference Proceedings. American Society of Engineering Education Mid-Atlantic Regional Conference, October 2016.
http://www.hofstra.edu/academics/colleges/seas/seas-fall16-asee-conference-papers.html

Bull, G.R., Oakley, J.O., and Corradini, M.L., "Effects of Bubble Injection on Heat Transfer from a Volumetrically Heated Water Pool." *Nuclear Science and Engineering*, 2015, **180**, p. 301-311. http://dx.doi.org/10.13182/NSE14-79

10. Most recent professional development activities

ABET Fundamentals of Assessment Workshop, April 2018.

1. Name

F. John Burpo Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

Sc.D., Bioengineering, Massachusetts Institute of Technology, 2012

M.S., Chemical Engineering, Stanford University, 2002

B.S., Mechanical-Aerospace Engineering, United States Military Academy, 1992

3. Academic experience – institution, rank, title, dates, full or part time

Nine years (USMA, Full Time, 2002-2004, 2012-present): Associate Professor (2019); Assistant Professor (2003).

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Technical Military Assignments: (all Full Time) - Deputy Commander, 20th Chemical, Biological, Radiological, Nuclear, and Explosives Command, Aberdeen Proving Ground, MD (2014-2015); Operations Officer, Fort Lewis, WA (2005-2008); Division Artillery Supply Officer, Battery Commander, Fort Hood, TX (1997-2000); Fire Support Officer, Executive Officer, Vicenza, Italy (1993-1996).

5. Certifications or professional registrations

EIT, New York (1992)

6. Current membership in professional organization

American Chemical Society (ACS), Materials Research Society (MRS), Biomedical Engineering Society (BMES), Field Artillery Association

7. Honors and awards

Academic and Professional: Koch Institute Scientific Image Award (2011). Director's Prize, MIT Institute of Soldier Nanotechnologies Soldier Design Competition (Team Mentor; 2011). Selected for U.S. Army Artillery Tactical Battalion Command (2007). Command & General Staff College MacArthur Writing Award (2005).

Military: Combat Action Badge, Senior Parachutist Badge, Air Assault Badge, Ranger Tab, German Jump Wings, Bronze Star, Purple Heart, Meritorious Service Medal (4), Army Commendation Medal (6), Army Achievement Medal (2).

8. Service activities (within and outside of the institution)

Institutional Service: Head, Department of Chemistry & Life science (2017-Present); Deputy Department Head (2014-2017); Life Science Program Director (2013-214); Co-Chair, Middle States Accreditation, Standard IV (2017-Present); Member, Math, Science & Engineering Committee (2016-Present); Chair, Memorialization, History, and Museum Committee (2017-Present); Member, Academic Board, General Committee, Class Committees (2014-Present).

Professional Service: Journal Reviewer (16 reviews) for Molecules, Materials, Advanced Engineering Materials, Coatings, ACS Omega, Forests, Chemistry of Materials, Applied Sciences; Defense Health Agency Small Business Innovation Research (SBIR) Program Grant Technical Reviewer (2015-2018); Edgewood Chemical Biological Center (ECBC), Technology Advisory Board Member (2014-Present). Army Research Office, Extramural Research Review, Board of Visitors member (2013-2015). Institute for Collaborative Biotechnologies (ICB) grant reviewer (2012-2015). Assistant Secretary of Defense for Research and Engineering (ASDR&E)-Future Directions in Synthetic Biology for Energy Storage and Power Delivery, workshop/report member (2018).

9. Publications (20) and presentations (34) from the past five years

F. John Burpo*, Enoch A. Nagelli, Joshua P. McClure, Anchor R. Losch, Jack Bui, Gregory T. Forcherio, David R. Baker, Joshua P. McClure, Stephen F. Bartolucci, Deryn D. Chu. "Salt-Templated Platinum-Copper Porous Macrobeams for Ethanol Oxidation." *Catalysts*, 2019, *9*(8), 662.

Veasna Soum, Sooyoung Park, Albertus Ivan Brilian, Yunpyo Kim, Madeline Y. Ryu, Taler Brazell, **F. John Burpo**, Kevin Kit Parker, Oh-Sun Kwon and Kwanwoo Shin. "Inkjet-Printed Carbon Nanotubes for Fabricating a Spoof Fingerprint on Paper." *ACS Omega*, 2019, 4, 8626−8631.

Alexander N. Mitropoulos*, **F. John Burpo*,** Chi K. Nguyen, Enoch A. Nagelli, Madeline Y. Ryu, Jenny Wang, R. Kenneth Sims, Kamil Woronowicz, J. Kenneth Wickiser. "Noble metal composite porous silk fibroin aerogel fibers." *Materials*, 2019, 12(6) 894.

Jacqueline Ohmura, **F. John Burpo**, Chamille Lescott, Alan Ransil, Youngmin Yoon, William Records, Angela Belcher. "Highly adjustable 3D nano-architectures and chemistries via assembled 1D biological templates." *Nanoscale*, 2019, 11, 1091-1102.

F. John Burpo*, Enoch A. Nagelli, Stephen F. Bartolucci, Alexander N. Mitropoulos, Joshua P. McClure, David R. Baker, Anchor R. Losch, Deryn Chu. "Salt-Templated Platinum-Palladium Porous Macrobeam Synthesis." *MRS Communications*, 2019, 9(1), 280-287.

F. John Burpo*, Enoch A. Nagelli, Lauren A. Morris, Kamil Woronowicz, Alexander N. Mitropoulos. "Salt-Mediated Au-Cu Nanofoam and Au-Cu-Pd Porous Macrobeam Synthesis." *Molecules*. 2018, *23*, 1701-171.

F. John Burpo*, Alexander N. Mitropoulos, Enoch A. Nagelli, Jesse L. Palmer, Lauren A. Morris, Madeline Y. Ryu, J. Kenneth Wickiser. "Cellulose Nanofiber Biotemplated Palladium Aerogels." *Molecules*. 2018, *23*, 1405-1418.

F. John Burpo*, Enoch A. Nagelli, Stephen J. Winter, Joshua P. McClure, Stephen F. Bartolucci, Alvin R. Burns, Sean F. O'Brien. "Salt-Templated Hierarchically Porous Platinum Macrotube Synthesis." *ChemistrySelect*. 2018, *3*, 4542-4546.

10. Most recent professional development activities

Annual departmental faculty development workshops - certified all new faculty (2016-Present).

1. Name

Jeffrey Chin — Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

M.S., Engineering Management, Missouri University of Science and Technology, 2015
B.S., Chemical Engineering, United States Military Academy, 2010

3. Academic experience – institution, rank, title, dates, full or part time

USMA, Instructor, 2020 –

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Military Assignments: (all fulltime)

Company Commander, 937th Route Clearance Company, 36th Engineer Brigade, Bagram Army Air Field, Afghanistan & FT Hood, Texas (2016-2018); Future Plans Officer, 20th Engineer Battalion, 36th Engineer Brigade, FT Hood (2015-2016); Division Facility Sustainment, Restoration, and Modernization Program Manager, 1st Special Forces Command (Provisional), FT Bragg (2013-2014); Security Forces Advise and Assist Engineer Company Advisor, 3rd Brigade Combat Team, 4th Infantry Division, Kandahar Province, Afghanistan (2012); Platoon Leader, Mechanized Engineer Platoon, 3rd Special Troops Battalion, 3rd Brigade Combat Team, 4th Infantry Division, FT Carson (2011 & 2013); Assistant Operations Officer/ Task Force Engineer, 1st Battalion, 8th Infantry Regiment, 4th Infantry Division, Camp Gary Owen, Iraq & FT Carson (2010-2011).

5. Certifications or professional registrations

Engineer Officer Basic Course qualification; Airborne qualification; Engineer Captain's Career Course (SCCC) qualification; Fundamentals of Engineering Exam, Delaware, APR10; Project Management Professional (PMP).

6. Current membership in professional organization

Project Management Institute (PMI)

7. Honors and awards

Academic:

Military: Bronze Star Medal, Meritorious Service Medal, Army Commendation Medal (4), Army Achievement Medal, National Defense Service Medal, Afghanistan Campaign Medal (2), Iraq Campaign Medal, Global War on Terror Service Medal, Army Service Medal, Overseas Service Medal (2)

8. Service activities (within and outside of the institution)

Institutional Service: Served as the treasurer and then president for the USMA cadet Chemical Engineering Club (2008-2010).

Professional Service:

9. Publications and presentations from the past five years

N/A

10. Most recent professional development activities

University of Washington Chemical Engineering Graduate Seminar Series (2018-2019); University of Washington Graduate Student Symposium (2018 & 2019)

1. Name
Trevor Corrigan Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year
M.S. in Chemical Engineering, University of Washington, Seattle, WA
B.S. in Chemical Engineering, United States Military Academy, West Point, NY

3. Academic experience – institution, rank, title, dates, full or part time
USMA, Instructor, 2018-

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time
Military Assignments: (all fulltime)
Instructor & S-4 Department of Chemistry and Life Science, United States Military Academy Student Detachment; Company Commander, Apache Company, 2-35 IN Regt, 25th Infantry Division, Schofield Barracks Hawaii (August 2015 – May 2016); Company Commander, HHC, 2-35 IN Regt, 25th Infantry Division, Schofield Barracks Hawaii (September 2014 – August 2015); Ranger Company Executive Officer, Bravo Company 2nd Battalion, 75th Ranger Regiment, Fort Lewis, Washington (Deployed twice in support of Operation Enduring Freedom, Afghanistan) (January 2012 – October 2013); Ranger Platoon Leader, Bravo Company 2nd Battalion, 75th Ranger Regiment, Fort Lewis Washington (Deployed twice in support of Operation Enduring Freedom, Afghanistan) (November 2010 – December 2011); Stryker Platoon Leader, Blackhorse Company, 2-3 IN Regiment, 2nd Infantry Division, Fort Lewis Washington (Deployed in support of Operation Iraqi Freedom) (May 2009 – October 2010).

5. Certifications or professional registrations
Infantry Officer Basic Course qualification; Ranger qualification; Airborne qualification; Jump Master Course; Maneuver Captain’s Career Course (MCCC) qualification; Fundamentals of Engineering Exam, Delaware, APR08.

6. Current membership in professional organization
American Institute of Chemical Engineers (AIChE)

7. Honors and awards
Military: Bronze Star Medal(2), Meritorious Service Medal, Army Valorous Unit Award, Army Commendation Medal (2), Army Achievement Medal, National Defense Service Medal, Afghanistan Campaign Medal(2), Iraq Campaign Medal(2), Global War on Terror Service Medal, Army Service Medal, Overseas Service Medal (5), NATO Medal, Combat Infantryman’s Badge, and Expert Infantryman’s Badge.

8. Service activities (within and outside of the institution)

Institutional Service: Cadet Sponsorship Program; West Point AIChE Chapter Assistant Officer-in-Charge; Leader Challenge Mentor, Cadet Leader Development Training Platoon Mentor, Faculty Development Mentor, Department Academic Counselor; Served as Department Budget and Supply Officer.

9. Publications and presentations from the past five years

Presented master’s thesis entitled “Hunt for a Genetically Engineered, Rationally Designed, Stealth Peptide to Prevent Non-Specific Protein Interactions” during the department seminar series. West Point, NY (Fall 2018)

10. Most recent professional development activities

U.S. Military Academy Master Teacher Program. (Fall 2018— Present)

Intermediate Level Education (Command and General Staff College) Distance Learning (2019—Present)

1. Name
Sam Cowart Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year
Ph.D., Chemical Engineering, University of North Dakota, 2020 (expected)
M.S., Chemical Engineering, University of North Dakota, 2012
B.S., Chemical Engineering, University of North Dakota, 2002

3. Academic experience – institution, rank, title, dates, full or part time
USMA, Instructor, 2012-2013
USMA, Assistant Professor, 2013-2014

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time
Military Assignments:
Operations Officer, 3rd Battalion, 321st Field Artillery Regiment, Fort Bragg (2016-2017); Executive Officer, 3rd Battalion, 321st Field Artillery Regiment, Fort Bragg (2015-2016); Brigade Effects Officer, 18th Field Artillery Brigade, Fort Bragg (2014-2015); Assistant Professor, Department of Chemistry & Life Science, United States Military Academy; Battery Commander, 1st Battalion, 41st Field Artillery, Fort Stewart (2008-2010); Squadron Fire Support Officer, 5th Squadron, 7th Cavalry, Fort Stewart (2007-2008); Assistant Operations Officer, 1st Battalion, 41st Field Artillery, Fort Stewart (2006-2007); Battery Executive Officer, 2nd Battalion, 8th Field Artillery, Fort Lewis (2004-2006); Cannon Platoon Leader & Fire Direction Officer, 2nd Battalion, 8th Field Artillery, Fort Lewis (2003-2004); Company Fire Support Officer, 1st Battalion, 24th Infantry, Fort Lewis (2002-2003).

5. Certifications or professional registrations
Field Artillery Officer Basic Course qualification; Airborne qualification; Field Artillery Captain's Career Course (FACCC) qualification; Intermediate Level Education qualification.

6. Current membership in professional organization
American Institute of Chemical Engineers (AIChE)
Association of the United States Army (AUSA)
US Field Artillery Association (USAFA)

7. Honors and awards
Military: Bronze Star Medal (3), Meritorious Service Medal (4), Army Commendation Medal (2), Army Achievement Medal, National Defense Service Medal, Iraq Campaign Medal, Global War on Terror Service Medal, Global War on Terror Expeditionary Medal, Army Service Medal, Overseas Service Ribbon (4)

8. Service activities (within and outside of the institution)
Institutional Service: Cadet Sponsorship Program; Company Academic Counselor; Army Hockey Officer Representative
Professional Service:

9. Publications and presentations from the past five years

Pending update – manuscript under review with *Applied Thermal Engineering*

10. Most recent professional development activities

General Chemistry Laboratory Assistant Course Director, CH101A Course Director

1. Name

Corey James Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

Ph.D., Chemical Engineering, University of Texas, 2017
M.S., Chemical Engineering, University of Texas, 2009
B.S., Chemistry and Life Science, United States Military Academy, 1999

3. Academic experience – institution, rank, title, dates, full or part time (all full-time)

USMA, Instructor and Assistant Professor, 2009-20128
USMA, Academy Professor, 2017-present

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Military Assignments: (all full-time)
Chemical Engineering Assistant Program Director (2018-present); Deputy Director, Center for Molecular Science, USMA 2017-2018; S3, Operations Officer for 2-159 Aviation Battalion Task Force.; Company Commander, D/1-4 Attack Reconnaissance Battalion (2004-2006); Platoon Leader (2000-2003)

5. Certifications or professional registrations

AH-64D Maintenance Test Pilot; Army Aviation Maintenance Manager's Course; AH64D Qualification Course, Aviation Captain's Career Course; AH64A Qualification Course; Army Aviation Officer Basic Course; Army Aviation Rotary Wing Aviator Course.

6. Current membership in professional organization

American Institute of Chemical Engineers (AIChE)
Society for Industrial and Applied Mathematics (SIAM)

7. Honors and awards

Academic: Academy Professor
Military: Bronze Star(3xOLC), Meritorious Service Medal (3xOLC), Army Commendation Medal (2xOLC), Army Achievement Medal, National Defense Service Medal (2), Armed Forces Expeditionary Medal, Global War on Terror Service Medal, Armed Forces Service Medal, Humanitarian Service Medal, Army Service Ribbon, Overseas Service Ribbon (3), NATO Medal

8. Service activities (within and outside of the institution)

Institutional Service: Curriculum Committee; Academy Professor Search Committee (EECS); Chair, Title 10 Assistant Professor Search Committee; Rotating Faculty Search Committee (3); Department Academic Counselor; Army Hockey Team Officer Representative; SCUBA Team Officer-in-Charge
Professional Service: Institute for Collaborative Biotechnologies (ICB) grant reviewer (2010-2012); Reviewer, IEEE Conference on Control Technology and Applications (2017-present)

9. Publications and presentations from the past five years

Matthew J. Armstrong, Joshua P. White, Jesse W. Hudgins, Geoffrey R. Bull, **Corey M. James**, Dawn E. Riegner, April D. Miller, and Andrew Biaglow. "Developing Chemical Engineering Acumen by Brewing Kicking Mule Beer." *Chemical Engineering Education* 53, no. 2 (2019): 101.

Corey M. James*, Michael E. Webber, and Thomas F. Edgar. "Minimizing the Effect of Substantial Perturbations in Military Water Systems for Increased Resilience and Efficiency." *Processes* 5, no. 4 (2017): 60.

J. Scott Vitter and **Corey M. James**. "In a Position to Lead: How Military Technology and Innovation Can Ease the World's Water Challenges." *Earth Magazine*, August 2017, pp. 24-31.

Anthony Burgess and **Corey M. James**. "The Pro-Reading Challenge: One Achievable Step for Leader Development". *ARMY Magazine*, February 2011, pg. 49.

Corey M. James, "Optimization and Control of Energy in Combat Systems to Maximize Efficiency and Effectiveness". Army Research Laboratory Advanced Power Electronics Workshop, Austin, TX, 2019. **(Oral)**

Corey M. James, "In a Position to Lead: How Military Technology and Innovation Can Ease the World's Water Challenges". Panel at the USMA Dean's "A Celebration of West Point Authors", West Point, NY, 2018. **(Oral)**

Corey M. James, "Some Considerations for Managing Municipal Water…and Energy". Panel titled "Flexible Operation of Water Infrastructure to Provide Electricity System Services*", IEEE Innovative Smart Grid Technologies Conference*, Washington, D.C., 2018. **(Oral)**

Corey M. James, "Water: Can We Change Course?". *TedX*. West Point, NY, 2018. **(Oral)**

10. Most recent professional development activities

Army Research Lab-Power and Energy Branch Grant: *Optimization and Control of Energy in Combat Systems to Maximize Efficiency and Effectiveness,* USMA Technical POC/PI, $180,000 (2019-2021).

Army Intermediate Level Education (2012).

1. Name
Eileen M. Kowalski Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year
Doctor of Philosophy, Chemistry, Vanderbilt University, 1999
Master of Science, Chemistry, Vanderbilt University, 1996
Bachelor of Arts, Chemistry, Western Michigan University, 1992

3. Academic experience – institution, rank, title, dates, full or part time
USMA, Assistant Professor, 2001-2007, Full Time
USMA, Associate Professor, 2007-present, Full Time

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time
Tennessee Department of Agriculture, Food Residue Laboratory, Chemist, Nashville, TN (1999-2001, full time); The Upjohn Company, Intern and Technician, Portage, MI (1991-1992, part time).

5. Certifications or professional registrations
none

6. Current membership in professional organization
American Chemical Society

7. Honors and awards
Superintendent's Certificate of Appreciation (2017), Gamma Sigma Epsilon Chemistry Honors Society (2009), Patriotic Civilian Service Award (2007), Master Teacher Program Certificate (2004).

8. Service activities (within and outside of the institution)
Institutional Service: USMA Policy Board (2013- present); Chemistry Program Director (June 2018- present); Department Academic Counselor (2006-present), Head Department Academic Counselor (2009-2018); Center for Teaching Excellence Advisory Committee (2004-2005, 2006-present); Army Cross Country and Track & Field Teams Officer Representative (2002-present)
Professional Service: The POGIL Project,™ strategic planning and resource development

9. Publications and presentations from the past five years

Books and Book Chapters: none

Journal Articles:
N. Ulrich, T. Spudich, E. Kowalski, M.Z. Kalainoff. "An open-source, web-based math solver for solving multi-variable equilibrium problems in general chemistry". *Committee on Computers in Chemical Education Newsletter*, Spring 2018.

Conference Proceedings:

C. Fish, A. Mahoney, S. Garrett-Roe, A. Grushow, S.S. Hunnicutt, B. Fetterly, M.P. Garoutte, E.M. Kowalski, A.E. Martin, R. Pongdee, M.S. Reeves, and C.M. Teague. "Development of the POGIL Activity Clearinghouse (PAC)." *Spring 2019 ACS National Meeting*, April 2019.

E.M. Kowalski, M.Z. Kalainoff. "How changing discourse patterns in general chemistry classes changed our learning goals and exams." *2018 Biennial Conference on Chemical Education*, August 2018.

E.M. Kowalski. "Comparison of learning objectives from traditional and guided-inquiry general chemistry courses." *2017 Gordon Research Conference on Chemistry Education Research & Practice*, June 2017.

L. Fallot, M. Kalainoff, and E. Kowalski. "Peeking inside the black box: Making learning visible using an ethnographic perspective." *Spring 2017 American Chemical Society National Meeting*, April 2017.

E.M. Kowalski, M.Z. Kalainoff. "Comparison of mid-term exams from traditional and guided-inquiry general chemistry courses." *2016 Biennial Conference on Chemical Education*, August 2016.

A. Armour and E.M. Kowalski. "Characterization of Common RDX Degradation Pathways using GC/MS and Proton NMR." *Proceedings of the 23rd Annual ARL/USMA Technical Symposium*, October 2015.

E.M. Kowalski, A. Chase, and R.L. Comitz. "Implementing an Inquiry-Based Multistep Synthesis in an Organic Chemistry Laboratory Course." *2015 Gordon Research Conference on Chemistry Education Research & Practice*, June 2015.

Patents: none

10. Most recent professional development activities

Annual departmental faculty development workshops

1. Name

April Miller Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

Ph.D., Chemical and Biomolecular Engineering, University of Nebraska-Lincoln, 2017
M.S., Nuclear Engineering, Air Force Institute of Technology, 2011
M.S., Environmental Management, Webster University, 2006
B.S., Chemical Engineering, Clarkson University, 2000

3. Academic experience – institution, rank, title, dates, full or part time

USMA, Assistant Professor, 2017-Present

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Military Assignments: (all fulltime)

Assistant Professor (2017-Present); Executive Officer to the Deputy Commander, U.S. Strategic Command Center for Combating WMD (2013-2014); CWMD Planner, U.S. Strategic Command Center for Combating WMD (2011-2013); Nuclear Planner, 20th Support Command (2009); Chemical, Biological, Radiological, Nuclear and High Yield Explosives (CBRNE) Response Team (CRT) Leader, 22nd Chemical Battalion (Technical Escort) (2008-2009); Company Commander, Headquarters and Headquarters Company (HHC), 22nd Chemical Battalion (Technical Escort) (2007-2008); Watch Officer, Engineer Brigade, 1st Calvary Division, Baghdad, Iraq (2005); Operations Officer, Governorate Support Team, 1st Calvary Division, Baghdad, Iraq (2004); Seaport of Embarkation and Debarkation Chemical, Biological, Radiological and Nuclear (CBRN) Response Platoon Leader, 68th Chemical Company, Kuwait and Iraq (2003); Brigade CBRN Officer and Intelligence Officer, Engineer Brigade, 1st Calvary Division, Fort Hood, Texas (2002-2003); Battalion CBRN Officer, 2-2 Aviation Battalion, 2nd Infantry Division, Camp Stanley, Korea (2001-2002)

5. Certifications or professional registrations

Chemical Officer Basic Course qualification; Chemical Captain’s Career Course (CMCCC) qualification; Joint and Combined Warfighting qualification; Intermediate Level Education qualification; Nuclear and Counterproliferation qualification; Technical Escort qualification; CBRN Reconnaissance qualification

6. Current membership in professional organization

American Institute of Chemical Engineers (AIChE)

7. Honors and awards

Academic: Tau Beta Pi

Military: Bronze Star Medal, Defense Meritorious Service Medal, Meritorious Service Medal, Joint Service Commendation Medal, Army Commendation Medal (4), Army Achievement Medal, National Defense Service Medal, Iraqi Campaign Medal, Global War on Terror Service Medal, Korea Defense Service Medal, Army Service Medal, Overseas Service Medal (2), Combat Action Badge

8. Service activities (within and outside of the institution)

Institutional Service: Cadet Sponsorship Program; West Point AIChE Chapter Officer-in-Charge; West Point Chocolate Factory Officer-in-Charge; Army Boxing Academic Officer; Army Taekwondo Assistant Officer-in-Charge; Atom's Youth Hockey Assistant Coach; 3-on-3 Youth Hockey Assistant Coach; Dean's Teaching Award Committee Member

9. Publications and presentations from the past five years

Sahu, N., **Miller, A.D**., Budhiraja, G., Viljoen, H.J., Subramanian, A. Continuous Low-Intensity Ultrasound Promotes Integration between Native-to-Native Cartilage Interfaces. Tissue Engineering. (Accepted, 2019).

Armstrong, M., White, J.P., Hudgins, J.W., Bull, G.R., James, C.M., Riegner, D.E., **Miller, A.D**. and Biaglow, A. DEVELOPING CHEMICAL ENGINEERING ACUMEN by Brewing Kicking Mule Beer. Chemical Engineering Education, 53(2), p.101. (2019)

Miller, A.D., Armstrong, M.J., James, C. "Comparison of Global, Stochastic Optimization Algorithms Using Toy Problems and Multi-Parameter Models to Kinetic Fermentation and Rheological Data." Presented at the Annual American Institute of Chemical Engineering (AICHE) Conference in Pittsburgh, PA on 30 OCT 2019.

Miller, A.D., Subramanian, A. and Viljoen, H.J., 2017. Theoretically proposed optimal frequency for ultrasound induced cartilage restoration. Theoretical Biology and Medical Modelling, 14(1), p.21. (Nov 2017)

Miller, A.D., Chama, A., Louw, T.M., Subramanian, A. and Viljoen, H.J. Frequency sensitive mechanism in low-intensity ultrasound enhanced bioeffects. PloS one, 12(8), p.e0181717. (Aug 2017)

Miller, A.D., Subramanian, A. and Viljoen, H.J. A nonlinear model of cell interaction with an acoustic field. Journal of biomechanics, 56, pp.83-88. (May 2017)

Miller, A.D. Mathematical Modeling of Ultrasound in Regenerative Medicine: From the Cellular Scale to the Macroscale (Doctoral dissertation, The University of Nebraska-Lincoln). (May 2017)

Thakurta, S.G., Sahu, N., **Miller, A.,** Budhiraja, G., Akert, L., Viljoen, H. and Subramanian, A. Long-term culture of human mesenchymal stem cell-seeded constructs under ultrasound stimulation: evaluation of chondrogenesis. Biomedical Physics & Engineering Express, 2(5), p.055016. (Sep 2016)

10. Most recent professional development activities

Master Teacher Program Graduate (2019)

1. Name
Enoch A. Nagelli Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year
Ph.D., Chemical Engineering, Case Western Reserve University, 2014
M.Eng., Chemical Engineering, Illinois Institute of Technology, 2009
B.S., Bioengineering, University of Illinois at Chicago, 2005

3. Academic experience – institution, rank, title, dates, full or part time
USMA, Assistant Professor, 2016-Present
ARPA-E Postdoctoral Scholar, Case Western Reserve University, 2014-2016
AFRL/DAGSI Graduate Student Fellow, Case Western Reserve University, Wright-Patterson Air Force Base, 2009-2014

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time
Biomedical Infusion Systems Analyst, Baxter International Inc., Full Time, 2006-2007

5. Certifications or professional registrations
Member of the Order of The Engineer

6. Current membership in professional organization
American Institute of Chemical Engineers (AIChE)
Electrochemical Society (ECS)
American Chemical Society (ACS)

7. Honors and awards
Academic: Superintendent’s Coin for Excellence of Scholarship and Cadet Development (2019), Achievement Medal for Civilian Service from Department of the Army (2018), AFRL/GAGSI Graduate Research Fellowship (2009).

8. Service activities (within and outside of the institution)
Institutional Service: West Point AIChE Chapter Assistant Officer-in-Charge; Department Academic Counselor (DAC); Member of Superintendent’s USMA Faculty Council for Diversity and Inclusion for STEM; Department Trusted Agent for Course End Feedback; Member of Department Faculty Selection Committee; Assistant Officer Representative (OR) for the USMA Men’s Basketball Team.
Professional Service: Co-Guest Editor for Molecules Special Issue (2019-Present); NSF Graduate Research Fellowship Program (GRFP) Reviewer (2019)

9. Publications and presentations from the past five years

Select Publications

Steven Selverston, **Enoch A. Nagelli**, Jesse Wainright, and Robert Savinell "All-Iron Hybrid Flow Batteries with In-Tank Rebalancing" *J. Electrochem. Soc.* 2019 166 (10) A1725-A1731.

F. John Burpo, **Enoch A. Nagelli**, Alexander N. Mitropoulos, Stephen F. Bartolucci, Joshua P. McClure, David R. Baker, Anchor R. Losch, Deryn Chu. "Salt-Templated Platinum-Palladium Porous Macrobeam Synthesis." *MRS Communications* 2019, 9, 280-287. doi:10.1557/mrc.2018.217

Nathaniel C. Hoyt, Ertan Agar, **Enoch A. Nagelli**, Robert Savinell and Jesse Wainright "Electrochemical Impedance Spectroscopy of Flowing Electrosorptive Slurry Electrodes" J. Electrochem. Soc.165 (10) E439-E444 (2018). Featured as Editor's Choice Article.

Enoch A. Nagelli, Liang Huang, Alvin Q.-Z. Dai, Feng Du, Liming Dai, "3D Vertically-Aligned CNT/Graphene Hybrids from Layer-by-Layer Transfer for Supercapacitors" *Part. Part. Syst. Charct.* 2017, 34, 1700131. Article in Special Issue of Graphene Oxide Liquid Crystals.

Select Presentations

Enoch A. Nagelli, An Vu, Kamil Woronowicz, F. John Burpo, Alexander Mitropoulos. "Self-Assembly of 3D Graphene/Carbon Nanotube Electrodes Via Electrostatic Polyanion Coordination for Biosensor Applications." American Institute for Chemical Engineers (AIChE) Annual Meeting. Pittsburg, PA, November 2018. (Oral)

Enoch A. Nagelli, Gabrielle Milanesa, F. John Burpo, Kamil Woronowicz, Alexander Mitropoulos. "Template-Free Self- Assembly of 3D Graphene/Noble Metal Nanotube Composite Electrocatalysts for Oxygen Reduction Reaction in Fuel Cells." American Institute for Chemical Engineers (AIChE) Annual Meeting. Pittsburg, PA, November 2018. (Oral)

Enoch A. Nagelli, Gabrielle Milanesa, Jenny Wang, An Vu, Benjamin Petrella, Kamil Woronowicz, Alexander N. Mitropoulos, F. John Burpo. "3D Graphene/Platinum Nanotube Hybrid Composite Electrodes via Electrostatic Self- Assembly for Supercapacitor Applications." ACS Northeast Nanomaterials Meeting (NENM 2018). Lake Placid, NY, June 2018. (Poster)

10. Most recent professional development activities

ABET's Fundamentals of Program Assessment Workshop (FPAW) at WEEF-GEDC in New Mexico (November 2018)

1. Name

Kamil Woronowicz Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

Ph.D., Chemistry, Yale University, 2005
M.S., Chemistry, Yale University, 2001
B.S., Chemistry with Biology minor, Wagner College, 1999

3. Academic experience – institution, rank, title, dates, full or part time

USMA, Assistant Professor, 2016-present, full time
Rutgers University, Coadjutant, 2015-2016, full time
Rutgers University, Instructor, 2011-2014, part time
Medgar Evers College, Senior Research Associate, 2011-2014, part time
Rutgers University, Senior Research Associate, 2011-2014, part time
USMMA, Adjunct Professor, 2011, part time
Wagner College, Adjunct Professor, 2009, part time
Rutgers University, Senior Research Associate, 2008-2011, full time
Harvard Medical School, NIH Postdoctoral Research Fellow, 2005-2008, full time

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

BK Biologics, LLC., co-founder, development of RNA silencing applications for use with cancer treatments and personal care, 2015, part time
Flex School, Inc., Science Educator, development of organic chemistry and biochemistry curricula for high school students and SAT/ACT prep, 2014-2015, full time
BioNanoTech, LLC., NSF I-Corps Entrepreneurial Lead, Lean Launch commercialization of a novel protein purification chromatography material, 2014, part time

5. Certifications or professional registrations

6. Current membership in professional organization

American Chemical Society (ACS)
International Society of Photosynthesis Research (ISPR)

7. Honors and awards

Omicron Delta Kappa, Beta Beta
NSF I-Corps: Commercialization of Immobilized Metal Affinity Chromatography
Resins Based on Nanomaterials, Division of Industrial Innovation and Partnerships, Award Number 1404605
NSF EAGER: A Hybrid Photosynthetic Electron Transport Chain Based on Graphene Oxide
Division of Chemical, Bioengineering, Environmental and Transport Systems, Award Number 1260073
NSF, The Assembly of Photosynthetic Light-Harvesting Complexes in Whole Cells, Division of Physics, Award Number 1057827

8. Service activities (within and outside of the institution)

Institutional Service: Kościuszko Squadron Assistant Officer-in-Charge
Professional Service: Co-Chair of Eastern Regional Photosynthesis Conference

9. Publications and presentations from the past five years

Peer-Reviewed Publications

Alexander N. Mitropoulos, F. John Burpo, Chi K. Nguyen, Enoch A. Nagelli, Madeline Y. Ryu, Jenny Wang, R. Kenneth Sims, **Kamil Woronowicz**, J. Kenneth Wickiser. "Noble metal composite porous silk fibroin aerogel fibers." *Materials*, 2019, 12(6) 894.

Burpo FJ, Nagelli EA, Morris LA, **Woronowicz K**, Mitropoulos AN. "Salt-Mediated Au-Cu Nanofoam and Au-Cu-Pd Porous Macrobeam Synthesis". *Molecules*. 2018, Jul 12;23(7).

Woronowicz K, Olubanjo OB, Sha D, Kay JM, Niederman RA. "Effects of the protonophore carbonyl-cyanide m-chlorophenylhydrazone on intracytoplasmic membrane assembly in Rhodobacter sphaeroides".*Biochim Biophys Acta*. 2015 Oct;1847(10):1119-28

Driscoll, B., Lunceford, C., Lin, S., **Woronowicz, K.,** Niederman, R.A., Woodbury, N.W. (2014) "Energy transfer properties of *Rhodobacter sphaeroides* chromatophores during adaptation to low light intensity". *Phys Chem Phys*, ***16****(32): 17133-17341*

Abstracts & Peer-Reviewed Conference Proceeding

Allen Gong, Enoch Nagelli, F. John Burpo, **Kamil Woronowicz***. "High Quantum Yield Conversion of Infrared Photons into Charge Separation Utilizing Photosynthetic Protein Complex on Graphene Oxide Electrode." Eastern Regional Photosynthesis Conference (ERPC), Woods Hole, MA, May 2019

Ross Poulin, F. John Burpo, **Kamil Woronowicz***, Enoch Nagelli. "Chemical Crosslinking Graphene Oxide with Deoxyribonucleic Acid and Protein Reaction Centers to Create Aerogels for Use in Biosensors." Eastern Regional Photosynthesis Conference (ERPC), Woods Hole, MA, May 2019

Alexander Hamilton, **Kamil Woronowicz***, Enoch Nagelli "Layer-by-Layer 3D Construction of Bacterial Photoreaction Centers with Graphene Oxide for Enhanced Photocurrent Generation in Organic Photovoltaics." Eastern Regional Photosynthesis Conference (ERPC), Woods Hole, MA, May 2019

10. Most recent professional development activities

2019-2024 PRC-ARO Photonics Research and Education at the United States Military Academy, Proposal Number 74787-PH

1. Name
Caspar C. Yi — Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year
M.S., Chemical Engineering, Cornell University, 2020
B.S., Chemical Engineering, United States Military Academy, 2011

3. Academic experience – institution, rank, title, dates, full or part time
USMA, Instructor, 2020 –

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time
Military Assignments: (all full time)

Chemistry and Chemical Engineering Instructor (July 2020 -); Company Commander, 7th Engineer Battalion, 1st Brigade Combat Team, 10th MTN DIV (LI), Fort Drum (2017 – 2018); Battalion S-4, Supply and Logistics Officer, 7th Engineer Battalion, 1st Brigade Combat Team, 10th MTN DIV (LI), Fort Drum (2016 – 2017); Team Leader, Engineer Captain's Career Course, Fort Leonard Wood (2015 – 2016); Battalion Plans Officer, 15th Engineer Battalion, 18th Military Police Brigade, Grafenwoehr, Germany (2014 – 2015); Company Executive Officer, Higher Headquarters Company, 18th Engineer Brigade, Schweinfurt, Germany (2013 – 2014); Route Clearance Platoon Leader, 42nd Clearance Company, 54th Engineer Battalion, 18th Engineer Brigade, Bamberg, Germany (2012 – 2013).

5. Certifications or professional registrations
Fundamentals of Engineering Exam, Delaware, APR11; Engineer-in-Training, Delaware; Engineer Basic Officer Leadership Course qualification; Air Assault qualification; Sapper qualification; Joint Engineer Operations Course (JEOC); Engineer Captain's Career Course (ECCC) qualification.

6. Current membership in professional organization
American Institute of Chemical Engineers (AIChE)
Golden Key International Honor Society
Society of Petroleum Engineers (SPM)

7. Honors and awards
Academic: Golden Key International Honor Society
Military: Bronze Star Medal for Valor, Bronze Star Medal, Meritorious Service Medal, Army Commendation Medal, Army Achievement Medal (3), National Defense Medal, Afghanistan Campaign Medal (2 Campaign Service Stars), Global War on Terrorism Service Medal, Army Service Ribbon, Overseas Service Ribbon (2), NATO Medal, Army Meritorious Unit Award, Sapper tab, Air Assault badge, Combat Action Badge

8. Service activities (within and outside of the institution)
Institutional Service: None
Professional Service: None

9. Publications and presentations from the past five years

Caspar Yi, Yong L. Joo, “Layer-on Layer Cathode Fabrication and Failure Mechanisms for High-Rate Lithium-Sulfur Batteries” *Poster presented at 2020 Chemical and Biomolecular Engineering Symposium in Ithaca, New York.*

Somayeh Zamani, George Shebert, **Caspar Yi**, Yong L. Joo, “Polysulfide entrapment and retardation in gel electrolyte Li-S batteries: experiments and modeling” *Journal of Materials Chemistry A*, Submitted 31 Dec 2019

10. Most recent professional development activities

Chemical Engineering Group Student Activities (CHEGSA) Master’s Representative

1. Name
Jack Cooperman Department of Electrical Engineering and Computer Science

2. Education
Master of Science, Electrical Engineering, University of Texas at Austin 2017
Bachelor of Science, Electrical Engineering, United States Military Academy 2008

3. Academic experience
Instructor, USMA (FT) 2017 - present

4. Non-academic experience
Army Officer 2008 - present

5. Certifications or professional registrations
Engineering Intern in the State of New York (093851)

6. Current membership in professional organization
Institute of Electrical and Electronic Engineers (IEEE); Power and Energy Society (PES)

7. Honors and awards
Distinguished Honor Graduate of the Signal Captain's Career Course 2013

8. Service activities
Institutional Service:
Department Academic Counselor 2017 - present
Company Academic Counselor 2018 - 2019
Facilitator, Leader Challenge 2017 - present
Volunteer, Cadet Character Education Team 2017 - present
Company Mentor, Cadet Leader Development Training 2018
Escort, USMA Board of Visitors Meeting 2018
Facilitator, USMA SHARP Stand Down 2019 - present
Assistant Officer-in-Charge, Amateur Radio Club 2019 - present

Professional Service:
None.

9. Most important publications and presentations from the past five years
R. Kimball, **J. Cooperman**, C. Fuhriman, E. Simpson, "A Study of Vertical Writing Surfaces at USMA," *Presentation at the* 2019 Clute International Academic Conference on Education, Las Vegas, Nevada, October 14-15, 2019.
https://www.cluteinstitute.com/conference-proceedings/lv19proceedings.pdf

10. Most recent professional development activities
Graduate of USMA Master Teacher Program 2019

1. Name
Duncan

1. Name

Steven L. Elgan Department of Electrical Engineering and Computer Science

2. Education

Master of Science, Mechanical Engineering, University of IL, Urbana 2011
Master of Arts, Information Technology Management, Webster University 2008
Bachelor of Science, Mechanical Engineering, United States Military Academy 2001

3. Academic experience

Assistant Professor, USMA (FT) 2018 - present
Instructor/Assistant Professor, USMA (FT) 2011 - 2014

4. Non-academic experience

Commander, 330th Transportation Battalion (Rear Provisional), Ft Bragg, NC 2017
Deputy G6, 3rd Expeditionary Sustainment Command, Ft Bragg, NC 2016
S3, 304th Exped Sig BN, 1st Signal Brigade, Camp Humphreys, Korea 2014 - 2016
Commander, Network Support Company, BSTB, 4IBCT, 1ID, Ft Riley, KS 2007 - 2009
Battalion S6, HHC, BSB, 4IBCT, 1st ID, Ft Riley, KS 2005 - 2007
Company XO, HHC, 3rd Signal BDE, Ft Hood, TX 2003 - 2004
Platoon Leader B Co, 57th Signal BN, Ft Hood, TX- MSE platoon 2002

5. Certifications or professional registrations

NA

6. Current membership in professional organization

Signal Corps Regimental Association; Society of the Big Red One.

7. Honors and awards

Squier Award Winner (Distinguished Honor Graduate) Signal Career Course 2006
Best Student Paper, GOMAC Tech Conference 2012

8. Service activities

Department Executive Officer 2019 - present
Officer Representative Track & Field/Cross Country 2018 - 2019
Platoon Mentor, Cadet Leader Development Training 2019
Facilitator, USMA SHARP Stand Down 2019 - present

9. Most important publications and presentations from the past five years

Carlson, H.-J. Kim-Lee, J. Wu, P. Elvikis, H. Cheng, A. Kovalsky, S. Elgan, Q. Yu, P.M., Ferreira, Y. Huang, K.T. Turner and J.A. Rogers, "Shear-enhanced Adhesiveless Transfer Printing for Use in Deterministic Materials Assembly," Applied Physics Letters 98,

S. Kim, J. Wu, A. Carlson, S.H. Jin, A. Kovalsky, P. Glass, Z. Liu, N. Ahmed, S.L. Elgan, W. Chen, P.M. Ferreira, M. Sitti, Y. Huang and J.A. Rogers, "Microstructured Elastomeric Surfaces with Reversible Adhesion and Examples of Their Use in Deterministic Assembly by

Transfer Printing," Proceedings of the National Academy of Sciences USA 107(40), 17095–17100 (2010).

S. Elgan, "Transfer Printed Mechanical MEMS," University of Illinois, (2011).

10. Most recent professional development activities

Executive Officer Dept of EECS 2019

1. Name
Joshua Groen Department of Electrical Engineering and Computer Science

2. Education
Master of Science, Electrical Engineering, University of Wisconsin 2017
Bachelor of Science, Electrical Engineering, Arizona State University 2007

3. Academic experience
Assistant Professor, USMA (FT) 2019 - present
Instructor, USMA (FT) 2017 - 2019

4. Non-academic experience
Telecommunications Systems Engineer, 50th Signal Battalion 2013 - 2015
Executive Officer, Headquarters & Headquarters Troop, 1-40 CAV 2010 – 2012
Scout Platoon Leader, A TRP, 1-40 CAV 2009 - 2010
Scout Troop Executive Officer, B TRP, 4-7 CAV 2009
Scout Platoon Leader, B TRP 4-7 CAV 2008

5. Certifications or professional registrations
Certified Information Systems Security Professional (CISSP) 2013

6. Current membership in professional organization
Institute of Electrical and Electronic Engineers (IEEE); Communications Society (COMSOC)

7. Honors and awards
Distinguished Military Honor Graduate, Arizona State University 2007

8. Service activities
Institutional Service:
Officer in Charge, Electronics Experimenters Club 2018 - present

9. Most important publications and presentations from the past five years
M. Haynes, **J. Groen**, E. Sturzinger, D. Zhu, J. Shafer, T. McGee, "Integrating Data Science into a General Education Information Technology Course," Proc. 20th Annu. Conf. Inf. Technol. Educ. (SIGITE '19), October 3 – October 5, 2019, Tacoma, WA.

J. Raftery, Jr., **J. Groen**, K. Ingold. "Beam Quality Factor Analysis for Coherently-Coupled Vertically-Emitting Laser Arrays." IEEE International Semiconductor Laser Conference, Sante Fe, 2018.

K. Ingold, J. Tate, **J. Groen**, B. Souhan, J. Raftery, Jr. "Beam Quality Factor Analysis of On-Wafer Vertical Cavity Surface Emitting Lasers." Conference on Lasers and Electro-Optics, San Jose, 2018.

J. Tate, K. Ingold, **J. Groen**, J. Raftery, Jr. "Evaluation of Beam Quality Study of Arbitrary Beam Profiles from On-Wafer Vertical Cavity Surface Emitting Lasers." National Conference on Undergraduate Research, Oklahoma City, 2018.

10. Most recent professional development activities

Completed requirements for USMA Master Teach Program
Completed US Army Command and General Staff College

1. Name

Peter David Hanlon — Department of Electrical Engineering and Computer Science

2. Education

Doctor of Philosophy, Electrical Engineering, Air Force Institute of Technology	1996
Master of Science, Electrical Engineering, Air Force Institute of Technology	1993
Bachelor of Science, Engineering, University of Central Florida	1985

3. Academic experience

Associate Professor, USMA (FT)	2009 - present
Assistant Professor, USMA (FT)	2000 - 2009
Instructor, USMA (FT)	1999 – 2000

4. Non-academic experience

Air Force Research Lab, Chief, Lethality and Vulnerability Branch	1997 – 1999
Air Force Research Lab, Program Manager, IUGS DARPA Project	1996 – 1997
Air Force Aeronautical System Division, Digital Systems Engineer	1989 – 1991
Air Force Geophysics Lab, Space Systems Engineer	1985 – 1989
6916th Electronic Security Squadron, Airborne Voice Processing Specialist	1981 – 1983

5. Certifications or professional registrations

Engineer in Training, FL	1986

6. Current membership in professional organization

Senior Member: Institute of Electrical and Electronic Engineers (IEEE)	2002 - present
Beta Kappa Nu Electrical Engineering Honor Society	1999 - present
Tau Beta Pi Engineering Honor Society	1985 – present

7. Honors and awards

USMA APGAR Teaching Award	2002

8. Service activities

Institutional Service:

Member of Superintendent's Civilian Faculty Advisory Committee	2012 – present
SCFAC Representative on the Academy Scheduling Committee	2015 - present
Multiple civilian and military faculty search committees	2007 - 2018
Officer in Charge, Crew	2001 - 2014
Officer in Charge, Women's Team Handball	2014 - present

Professional Service:

Reviewer for various journal and conference manuscripts	2000 - present

9. Most important publications and presentations from the past five years

Hanlon, P. D. and P. S. Maybeck, "Multiple Model Adaptive Estimation using a Residual Correlation Kalman Filter Bank," *IEEE Transactions on Aerospace and Electronic Systems*, vol. 36, no. 2., April 2000.

Hanlon, P. D. and P. S. Maybeck, “Characterization of Kalman Filter Residuals in the Presence of Mismodeling,” *IEEE Transactions on Aerospace and Electronic Systems*, vol. 36, no. 1. pp. 114–131, January 2000.

Hanlon, P. D. and P. S. Maybeck, “Interrelationship of Single-Filter and Multiple-Model Adaptive Algorithms,” *IEEE Transactions on Aerospace and Electronic Systems*, vol. 34, no. 3. pp. 934–946, July 1998.

Maybeck, P. S. and P. D. Hanlon, “Performance Enhancement of a Multiple Model Adaptive Estimator,” *IEEE Transactions on Aerospace and Electronic Systems*, vol. 31, no. 4. pp. 1240–1253, October 1995.

Hanlon, P. D. and J. H. Evers, “Detection of Thrust Vector Control Nozzle Failures Using Multiple Model Adaptive Estimation,” *AIAA Missile Sciences Conference*, Monterey, California, November 1998.

Hanlon, P. D. and P. S. Maybeck, “Multiple Model Adaptive Estimation using a Residual Correlation Kalman Filter Bank,” *IEEE Conference on Decision and Control*, Tampa, Florida, December 1998.

Hanlon, P. D. and P. S. Maybeck, “Characterization of Kalman Filter Residuals in the Presence of Mismodeling,” *IEEE Conference on Decision and Control*, Tampa, Florida, December 1998.

Hanlon, P. D. and P. S. Maybeck, “Performance Enhancement of a Multiple Model Adaptive Estimator,” *IEEE Conference on Decision and Control*, December 1994.

Doug Wolfe, Karl Gossett, Peter D. Hanlon, and Curtis A. Carver Jr. "Active Learning in a Freshman Information Technology Course" IEEE Frontiers in Education. Boulder, CO. November 5-8, 2003.

Hanlon, P. D. *Practical Implementation of Multiple Model Adaptive Estimation Using Neyman-Pearson Based Hypothesis Testing and Spectral Estimation Tools*, Ph.D. dissertation, Air Force Institute of Technology, 1996. Published as DTIC Technical Report.

Hanlon, P. D. *Practical Implementation of Multiple Model Adaptive Estimation Using Neyman-Pearson Based Hypothesis Testing and Spectral Estimation Tools*, MS Thesis. Air Force Institute of Technology, 1992. Published as DTIC Technical Report.

10. Most recent professional development activities

1. Name
Joseph L. Heyman Department of Electrical Engineering and Computer Science

2. Education
Doctor of Philosophy, Electrical and Computer Engineering, The Ohio State University 2019
Master of Science, Electrical and Computer Engineering, Carnegie Mellon University 2011
Bachelor of Science, Electrical Engineering, United States Military Academy 2002

3. Academic experience
Deputy Electrical Engineering Program Director, USMA (FT) 2019 - present
Assistant Professor, USMA (FT) 2019 - present
Researcher, Robotics Research Center, USMA (PT) 2019 - present
Assistant Professor, USMA (FT) 2013 - 2014
Instructor, USMA (FT) 2011 – 2013

4. Non-academic experience
Network Engineer, 101st Airborne Division 2014 - 2016
Assistant Lab Manager, TIC, Information Systems Engineering Command 2008 - 2009
Lead Test Engineer, TIC, Information Systems Engineering Command 2007 - 2008
Executive Officer, I Trp, 3rd Squadron, 3rd Armored Cavalry Regiment 2005 - 2006
Scout Platoon Leader, I Trp, 3rd Squadron, 3rd Armored Cavalry Regiment 2004 - 2005
Tank Platoon Leader, L Trp, 3rd Squadron, 3rd Armored Cavalry Regiment 2003 – 2004

5. Certifications or professional registrations
Certified Information Systems Security Professional (CISSP) 2016
Engineer in Training, NY 2002

6. Current membership in professional organization
Institute of Electrical and Electronic Engineers (IEEE); Society for Industrial and Applied Mathematics (SIAM)

7. Honors and awards
Advisor for Cadet's team in Synchronized Swimming Robotic Fish Competition,
team won 1st place prize. 2012
Squier Award Winner (Distinguished Honor Graduate), Signal Career Course 2007
Distinguished Honor Graduate, Telecommunication Systems Engineer Course 2006

8. Service activities
Institutional Service:
Department Academic Counselor 2019 – present
Electrical Engineering and Computer Science Character Development Committee 2019 – present
Electrical Engineering and Computer Science Website Committee 2019 – present

Professional Service:
None

9. Most important publications and presentations from the past five years

Heyman, Joseph, and Abhishek Gupta. "A fast algorithm to reduce 2× n bimatrix games to rank-1 games." In *2019 18th European Control Conference (ECC)*, pp. 1049-1054. IEEE, 2019.

Heyman, Joseph L., and Abhishek Gupta. "Colonel Blotto Game with Coalition Formation for Sharing Resources." In *International Conference on Decision and Game Theory for Security*, pp. 166-185. Springer, Cham, 2018.

10. Most recent professional development activities

Department faculty development workshop, Certified Information Systems Security Professional Course (CISSP), Various CISSP Continuing Professional Education (CPE) short courses, Participation and presentation in various conferences

1. Name

James J. Raftery, Jr. | Department of Electrical Engineering and Computer Science

2. Education

Doctor of Philosophy, Electrical Engineering, University of Illinois Urbana-Champaign	2005
Master of Strategic Studies, U.S. Army War College	2011
Master of Science, Electrical Engineering, University of Missouri - Columbia	1996
Bachelor of Science, Electrical Engineering, Washington University in St. Louis	1988

3. Academic experience

Department Head, USMA (FT)	2019 - Present
Deputy Department Head, USMA (FT)	2014 - 2019
Principal Associate Dean, USMA (FT)	2013 - 2014
Director Photonics Research Center, USMA (FT)	2011 - 2013
EECS Faculty, USMA (FT)	2005 - 2007
EECS Faculty, USMA (FT)	1996 - 1999

4. Non-academic experience

Special Staff, Cyber National Mission Force, Ft. Meade, MD	2015 - 2016
Product Manager Information Warfare, Ft. Meade, MD	2007 - 2010
Asst. Project Manager Soldier Power, PM Soldier Systems, Ft. Belvoir, VA	2001 - 2002
Power & Energy Research Manager, Army Research Lab, Adelphi, MD	1999 - 2002
Commander, 261st Signal Company, Hanau, Germany	1992 - 1993
Asst. Operations Officer, 102d Signal Battalion, Frankfurt, Germany	1991 - 1992
Platoon Leader, 228th Sign Company, Frankfurt, Germany	1989 - 1991

5. Certifications or professional registrations

Defense Acquisition Workforce Improvement Act - Program Manager	Level III
Defense Acquisition Workforce Improvement Act - Science & Technology Manager	Level III

6. Current membership in professional organization

American Society for Engineering Education (ASEE)	Member	2006
Institute of Electrical and Electronic Engineers (IEEE)	Senior Member	2006
Institute of Electrical and Electronic Engineers (IEEE)	Member	1995
Optical Society of America (OSA)	Member	1996

7. Honors and awards

Military Intelligence Corps Association Knowlton Award	2007
National Infantryman’s Association Order of St. Maurice	2002
Army Research Laboratory’s Achievement Award for Leadership	2001
Beta Kappa Nu (HKN) Electrical Engineering Honor Society	1988

8. Service activities

Institutional Service:

Credentials and Promotions Committee	2019 - Present
Academic Board	2018 - Present

General Committee	2018 - Present
Class Committee	2018 - Present
Policy Board	2018 - Present
Steering Committee	2018 - Present
Math, Science, and Engineering Committee	2018 - Present
Information Technology Strategy Committee	2018 - Present
Faculty Manual Committee	2016 - 2018
Cadet Extracurricular Activities Board	2013 - 2014
Plans and Resources Board	2013 - 2014
Academic Research Council	2011 - 2013
Faculty Council	2011 - Present
Various Faculty Search Committees	2011 - Present
Professional Service:	
CLEO Conference Semiconductor Laster Committee	2007 - 2010
Peer reviewer for various journal manuscripts	2011 - present

9. Most important publications and presentations from the past five years

Refereed Conference Proceedings:

J. J. Raftery, Jr., J. B. Groen, K. A. Ingold, "Beam Quality Factor Analysis for Coherently-Coupled Vertically-Emitting Laser Arrays," Proceedings of 28th International Semiconductor Laser Conference (ISLC2018), Santa Fe, NM (September 2018).

J. D. Tate, J. B. Groen, K. A. Ingold, **J. J. Raftery Jr.**, "Evaluation of Beam Quality Study of Arbitrary Beam Profiles from On-Wafer Vertical Cavity Surface Emitting Lasers," Proceedings of the 2018 National Conference for Undergraduate Research (NCUR), Edmond, OK, (2018).

CDT Jonathan Dencker, CDT Peter R. Zeidler, David Chacko, William North, Janice Blane, Kirk A. Ingold, Brian Souhan, and **James J. Raftery Jr**., "Characterization of single-mode vertical cavity surface-emitting lasers," Proceedings of the 2016 National Conference on Undergraduate Research (NCUR), Asheville, NC, (2016).

Conference Presentations:

K. A. Ingold, J. D. Tate, J. B. Groen, B. Souhan, **J. J. Raftery Jr**., "Beam Quality Factor Analysis of On-Wafer Vertical Cavity Surface Emitting Lasers," 2018 Conference on Lasers and Electro-Optics (CLEO), San Jose, CA (May 2018).

CDT B. Matsas, CDT C. Barthel, CDT M. Kuang, CDT J. Keith, J. L. Reilly IV, J. Trump, C. Rinke-Kneapler, **J. Raftery**, J. K. Wickiser, J. Ness, K. J. O'Donovan, "Serotonin Receptor Regulator P11 as a Putative Serum Biomarker of Depression," 2017 Military Health System Research Symposium (MHSRS). Kissimmee, FL (August 2017).

10. Most recent professional development activities

Operational Experience with Cyber National Mission Force	2015-2016

1. Name

Claude E. Barron IV (Jes) Department of Civil and Mechanical Engineering

2. Education

Bachelor of Science, Civil Engineering, U.S. Military Academy 2009
Master of Business Administration, Oklahoma State University 2015
Master of Science in Underground Construction & Tunnel Engineering, Colorado School of Mines 2018

3. Academic experience

Instructor, Civil Engineering, USMA (FT) 2018 - present

4. Non-academic experience

Geotechnical Engineer Intern, Brierley Associates Corporation 2017
U.S. Army Engineer Company Commander, 16th Engineer Battalion 2015 - 2016
U.S. Army Battalion Assistant Operations Officer, 16th Engineer Battalion 2014 - 2015
Project Manager, U.S. Army Corps of Engineers, Seattle District 2012 - 2013
U.S. Army Company Executive Officer, 864th Engineer Battalion 2011 - 2012
U.S Army Platoon Leader, 864th Engineer Battalion 2010 - 2011

5. Certifications or professional registrations

Professional Engineer (P.E.) Texas #118898
Project Management Professional (PMP) #1595958
LEED AP BD+C #10981017

6. Current membership in professional organization

American Society of Civil Engineers (ASCE), Geo-Institute
Society for Mining, Metallurgy, and Exploration (SME), Underground Construction Association (UCA)
Society of American Military Engineers (SAME)
Army Engineer Association (AEA)
Deep Foundations Institute (DFI)

7. Honors and awards

Bronze Star
Meritorious Service Medal
Army Commendation Medal

8. Service activities

Institutional Service:

Assistant to the Dean's representative for construction of the new Engineering Building
Officer Representative to the West Point Women's Soccer Team
Secretary for the Faculty Council

Professional Service:

Executive board member for the Underground Construction Association's Young Members group.

Defense Advanced Research Projects Agency (DARPA) Scientific Review Team Member for Broad Agency Announcement (Underminer) HR0011-18-2-0028
Provided technical assessment of a shotcrete wall design for Davis Barracks, West Point

9. Most important publications and presentations from the past five years
None

10. Most recent professional development activities
ASCE ExCEEd Conference Assistant Program Coordinator, USMA
Participating in the West Point Master Teacher Program
Taught project management to West Point faculty pursuing the project management professional (PMP) credential

1. Name

Brad Gregory Davis | Department of Civil and Mechanical Engineering

2. Education

Master of Science, Civil Engineering, University of Texas at Austin 2019
Master of Science, Engineering Management, Missouri S&T 2015
Bachelor of Science, Civil Engineering, United States Military Academy 2010

3. Academic experience

Instructor, USMA (FT) 2019 - present

4. Non-academic experience

Company Commander, 249TH Engineer Battalion, Fort Belvoir, VA (FT) 2017 - 2018
Logistics Officer, 249TH Engineer Battalion, Fort Belvoir, VA (FT) 2015 - 2017
Task Force Engineer, 75TH Ranger Regiment, Fort Benning, GA (FT) 2013 - 2015
Operations Officer, 173D IBCT (A), Bamberg, DE (FT) 2012 - 2013
Executive Officer, 173D IBCT (A), Bamberg, DE (FT) 2011 - 2012
Platoon Leader, 173D IBCT (A), Bamberg, DE (FT) 2010 - 2011

5. Certifications or professional registrations

Professional Engineer, MO 2015

6. Current membership in professional organization

American Society of Civil Engineers (ASCE); American Concrete Institute (ACI), American Institute of Steel Construction (AISC).

7. Honors and awards

None

8. Service activities

Institutional Service:

Officer in Charge, Cadet Scoutmaster's Council Club 20019 - present
Company and Department Academic Counselor 2019 - present

Professional Service:

ASCE ExCEEd Workshop Assistant Coordinator 2019

9. Most important publications and presentations from the past five years

None

10. Most recent professional development activities

Departmental faculty development workshops and new instructor seminars, ASCE ExCEEd Workshop; Product research, design and development, US Army Combat Capabilities Development Center, Picatinny Arsenal.

1. Name
Mark D. Evans Center for Teaching Excellence, Department of Civil and Mechanical Engineering

2. Education

Doctor of Philosophy, Geotechnical Engineering, Univ of California, Berkeley	1987
Master of Engineering, Geotechnical Engineering, Univ of California, Berkeley	1985
Master of Science, Geotechnical Engineering, Univ of California, Berkeley	1984
Bachelor of Science, Civil Engineering, Northeastern University	1981

3. Academic experience

Director, Center for Teaching Excellence, USMA (FT)	2006 – present
GeoMechanics Group Director, Civil Engineering Division, USMA (FT)	1998 – 2002
Associate Professor, USMA (FT)	1996 – present
Assistant Professor, Northeastern Univ. (FT)	1990 – 1996

4. Non-academic experience

GeoSyntec Inc., Norcross, Georgia, Project Engineer	1988-1990
CH2M Hill, Inc., Atlanta, Georgia, Geotechnical Engineer	1987-1988
GEI Consultants, Inc., Civil Engineer, Winchester, Massachusetts	1981-1983

5. Certifications or professional registrations
Registered Professional Engineer, NY

6. Current membership in professional organization
American Society of Civil Engineers (ASCE)
American Society for Engineering Education (ASEE)

7. Honors and awards

Outstanding Civilian Service Medal	2006
Journal of Professional Issues, ASCE, Best paper Award	2002
Education and Practice Publications Committee Exemplary Service Award, ASCE	2001
Fellow, American Society of Civil Engineers	2000
Commander’s Award for Civilian Service, US Military Academy	2000
Phi Kappa Phi Scholastic Achievement Award, USMA,	2000
Phi Kappa Phi, Member, USMA,	2000
ASCE Outstanding Faculty Advisor Award in Zone I	1995

8. Service activities
Institutional Service:

Deans Teaching Awards Committee Chair	2016 – present
Apgar and Adams Awards Committee Chair	2006 – present
Assistant Professor Promotion Committee	2016 – present
Cadet Climbing Team, Assistant Coach	2013 - present

Professional Service:

Associate Editor, Journal of Professional Issues, ASCE	2000-2003

Editor, Journal of Prof. Issues in Eng. Education and Practice, ASCE	1998 – 2000

9. Most important publications and presentations from the past five years

International Association of Chiefs of Police Annual Meeting, Clearwater, FL, Keynote Speaker	2018, 2019
Canadian Command and Staff College, Kingston, Ontario, CAN, two-day Teaching and Learning workshop	2018
Kazakhstan Military Academy, Two-day workshop on Teaching and Learning	2016
Peel Regional Police, Toronto, CAN, Teaching and Learning Workshop	2017

10. Most recent professional development activities

Master Teacher Program (MTP), USMA, 180 faculty enrolled in the program	2006 - present
CAN Command and Staff College, Kingston, Ontario, Master teacher Program	2015 – present
MTP with the US Army, Ft Leonard Wood, Engineer School,	2009 - 2015

1. Name
David Marshall Flaherty Department of Civil and Mechanical Engineering

2. Education
Master of Science, Civil Engineering, University of Colorado, Boulder 2017
Bachelor of Science, Civil Engineering, United States Military Academy 2007

3. Academic experience
Assistant Professor, USMA (FT) 2019 - present
Instructor, USMA (FT) 2017 - 2019

4. Non-academic experience
Attack Helicopter Company Commander, Fort Bragg, NC and Bagram, Afghanistan (FT)
2014 - 2015
Battalion Assistant Operations Officer, Fort Bragg, NC (FT) 2013 - 2014
Battalion Assistant Operations Officer, Fort Carson, CO and FOB Wolverine, Afghanistan (FT)
2011 - 2013
Attack Helicopter Platoon Leader, Fort Carson, CO (FT) 2010 - 2011
Distribution Platoon Leader, Fort Carson, CO (FT) 2009 – 2010

5. Certifications or professional registrations
Engineer in Training, NY 2007

6. Current membership in professional organization
American Society for Engineering Education (ASEE)

7. Honors and awards
C&ME Jared Mansfield Outstanding Teacher Award, USMA 2017
Bronze Star Medal 2015
Air Medal 2012 and 2015
Army Commendation Medal with Valor 2012
Army Commendation Medal 2013 and 2015
Senior Aviator Badge 2015
Combat Action Badge 2012
Air Assault Badge 2011

8. Service activities
Institutional Service:
T10 civilian faculty search committee 2019
Lead Coordinator, C&ME Instructor Summer Workshop, USMA 2018 - 2019
Asst. Head Department Academic Counselor 2018 - present
Leader Challenge Platoon Coach 2017 - present

9. Most important publications and presentations from the past five years

Flaherty, D. (2019), "The Critical Pick: A Crane Rigging Demonstration," Proceedings *of the American Society for Engineering Education (ASEE) 126th Annual Conference and Exposition*, Tampa, FL, June 16-19.

Miller, M., Rigney, J, Arnold, D. and **Flaherty, D.** (2019), "The Effects of Transitioning an Undergraduate Mechanical Engineering Course from Shorter and More Frequent Class Periods to Longer and Fewer In-Class Sessions," *Proceedings of the American Society for Engineering Education (ASEE) 126th Annual Conference and Exposition*, Tampa, FL, June 16-19.

10. Most recent professional development activities

Lead coordinator for departmental faculty development workshops and new instructor seminars, USMA; Participation and presentation at ASEE conference; Master Teacher Program, USMA

1. Name
Linford

1. Name

Brad Christopher McCoy — Department of Civil and Mechanical Engineering

2. Education

Doctor of Philosophy, Civil Engineering, North Carolina State University	2019
Master of Science, Civil Engineering, North Carolina State University	2011
Bachelor of Engineering, Civil Engineering, United States Military Academy	2001

3. Academic experience

Assistant Professor, USMA (FT)	2019-present
Guest Lecturer, NCSU (PT)	2017-2019
Assistant Professor, USMA (FT)	2013-2014
Course Director, USMA (FT)	2012-2014
Instructor, USMA (FT)	2011-2013

4. Non-academic experience

Battalion Operations Officer and Brigade Executive Officer, Ft. Riley, KS	2014-2016
Battalion Asst. Operations Officer and Company Commander, Ft. Bragg, NC	2006-2008
Battalion Asst. Operations Officer and Company Commander, Ghazni, Afghanistan	2007-2008
Aide-de-Camp, Baghdad, Iraq	2004-2005
Engineer Platoon Leader and Aide-de-Camp, Ft. Irwin, CA	2002-2004

5. Certifications or professional registrations

Professional Engineer, MO	2012
Envision® Sustainability Professional	2013

6. Current membership in professional organization

American Society of Civil Engineers (ASCE); American Society for Engineering Education (ASEE); Society of American Military Engineers (SAME); Institute for Sustainable Infrastructure (ISI).

7. Honors and awards

Grand Challenge Best Student Submission Award, ASCE	2019
C.C. Mangum Award for Graduate Research, NCSU	2019
1st Place Award, Three-Minute Thesis Competition, NCSU	2019
Beer and Johnston Outstanding New Mechanics Educator Award, ASEE	2014
Peter S. Michie Outstanding Teacher Award, USMA	2014
Distinguished Cadet Award, USMA	2001
Commandant's Award for Best Cadet Field Training Commander	2000

8. Service activities

Institutional Service:

Deputy Director, Center for Innovation and Engineering	2019-present
Member, Academic Research Council (ARC), USMA	2019-present
Member, ARC Faculty Research Fund Subcommittee	2019-present
Professional Military Ethic Leader Challenge Mentor	2011-2014; 2019-present

Officer Representative and Mentor, USMA Baseball Team	2011-2014; 2019-present
Department Academic Counselor	2011-2014; 2019-present
PL300 Military Leadership Mentor	2011-2014
Special Leader Development Program Mentor	2011-2014
Mentor and Instructor, C&ME Instructor Summer Workshop, USMA	2012-2014

Professional Service:

Vice-Chair, Sustainable Infrastructure Standard Committee, ASCE	2018-present
Committee Member, Academic Committee, ISI	2012-2014
Reviewer, ASCE	2013-present
Reviewer, ASEE	2012-2015

9. Most important publications and presentations

B. C. McCoy, Z. Bourara, R. Seracino, and G. W. Lucier (2019). "Anchor Bolt Patterns for Mechanically-Fastened FRP Plates," *Journal for Composites in Construction*. Vol. 23, No. 4, 16 pages, doi: 10.1061/(ASCE)CC.1943-5614.0000951.

B. C. McCoy (2019). *Design and Implementation of a New Retrofit for Prestressed Concrete Bridge Elements Using Mechanically-Fastened Fiber-Reinforced Polymer*, North Carolina State University, Doctoral Dissertation, 226 pp.

B. C. McCoy, Seracion, R., Lucier, G. W. (2019). "Rapid Restoration of Deteriorated Prestressed Concrete Bridges Using Mechanically-Fastened Fiber-Reinforced Polymer," *Proceedings of the ASCE Innovation Grand Challenge Contest Event*, Reston, Virginia.

B. C. McCoy, R. Seracino, G. L. Lucier, and T. W. Langerhans (2018). "DIC Strain Field Measurement of FRP Plates with and without Holes," *Proceeding for the 9th International Conference on Fiber-Reinforced Polymer Composites in Civil Engineering*. Paris, France, pp. 675-683.

B. C. McCoy, R. Seracino, and M. L. Leming (2015). "Modified Layered-Sectional Analysis for Forensic Investigation," *Journal of Performance of Constructed Facilities*. Vol. 29, No. 4, 11 pages, doi: 10.1061/(ASCE)CF.1943-5509.0000583.

B. C. McCoy, M. L. Leming, and R. Seracino (2014). "Crack Density and Elastic Properties of Sustainable Concretes," *ACI Materials Journal*. Vol. 111, No. 1, pp. 13-21.

B. Barry, S. Katalenich, **B. McCoy** (2012). "Student Perceptions of the Civil Engineering Body of Knowledge: Comparison of Two Academic Institutions," *Proceeding for the American Society of Engineering Education Annual Conference*, San Antonio, TX, pp. 25.1188.1-25.1188.18.

10. Most recent professional development activities

Departmental faculty development workshops and new instructor seminars, USMA; Presenting Data and Information Seminar, Raleigh, NC; Center for Integration of Composites into Infrastructure Industry Advisory Board, Raleigh, NC and Orlando, FL; Master Teacher Program, USMA.

1. Name

Kevin F. McMullen — Department of Civil and Mechanical Engineering

2. Education

Doctor of Philosophy, Structural Engineering, University of Connecticut 2019
Bachelor of Engineering, Civil Engineering, University of Connecticut 2015

3. Academic experience

Assistant Professor, USMA (FT) 2019 – Present

4. Non-academic experience

CEO/Co-Founder, NexGen Infrastructure, LLC. (PT) 2016-2019
Research Intern, Federal Highway Administration (FT) 2018
Project Engineering Intern, Skanska USA Building (FT) 2014
Structural Engineering Intern, Siefert Associates, LLC. (FT) 2013

5. Certifications or professional registrations

Engineer-in-Training, CT 2015

6. Current membership in professional organization

American Society of Civil Engineers (ASCE); American Institute of Steel Construction (AISC); Chi Epsilon, The National Civil Engineering Honor Society; Tau Beta Pi, The Engineering Honor Society

7. Honors and awards

University of Connecticut Civil and Environmental Engineering Graduate Fellowship 2018
Structural Engineering Institute Student Scholarship 2018
Pratt and Whitney Undergraduate Leadership, Teaching, and Mentoring Fellowship 2014

8. Service activities

Professional Service

Reviewer for the ASCE Journal of Bridge Engineering 2018-Present
Reviewer for the 2nd International Interactive Symposium on UHPC 2019
Explore Engineering (E2) at the University of Connecticut 2018

9. Most important publications and presentations from the past five years

McMullen, K., Zaghi, A. E., “Evaluation of UHPC as a Repair Material for Corroded Steel Bridge Girders.” *Second International Interactive Symposium on UHPC.* June 2-5, 2019, Albany, NY.

McMullen, K., Haber, Z., “Effect of Steel Reinforcement Diameter on the Strength of Non-contact Lap Splice Connections using UHPC.” *Second International Interactive Symposium on UHPC.* June 2-5, 2019, Albany, NY.

McMullen, K., Zaghi, A. E., “Experimental Testing of a Novel Force Sensing Bridge Bearing.” *Structures Congress, ASCE/SEI.* April 24-27, 2019, Orlando, FL.

Stromquist-LeVoir, G., **McMullen, K.,** Zaghi, A. E., Christenson, R., (2018) “Determining Time Variation of Cable Tension Forces in Suspended Bridges Using Time-Frequency Analysis” *Advances in Civil Engineering*, Vol. 2018, ID 1053232

McMullen, K., Zaghi, A. E., Culmo, M. "Repair of Corroded Steel Plate Girders with Ultra-High-Performance Concrete." *9th International Conference on Bridge Maintenance, Safety, and Management, IABMAS.* July 9-13, 2018, Melbourne, Australia.

McMullen, K., Zaghi, A. E., "Design of a Repair for Corroded Steel Girders Utilizing Ultra-High-Performance Concrete." *Structures Congress, ASCE/SEI.* April 19-21, 2018, Fort Worth, TX.

Zmetra, K., **McMullen, K.,** Zaghi A. E., Wille, K. (2017) "Experimental Study of UHPC Repair for Corrosion Damaged Steel Girder Ends" *Journal of Bridge Engineering, ASCE*, Vol. 22, No. 8.

McMullen, K., Kruszewski, D., Zaghi, A. E., Wille, K. "A Novel Repair Method for Steel Girders with Corrosion Damage Utilizing UHPC." *The International Bridge Conference, ESWP.* June 5-8, 2017, National Harbor, MD.

McMullen, K., Zaghi, A. E., Hoagland, M., Bokinsky, A. C. "Feasibility of Integrating Force Sensing Technology on PTFE Bearing Design." *8th World Congress on Joints, Bearings, and Seismic Systems for Concrete Structures*, September 25-29, 2016, Atlanta, GA.

10. Most recent professional development activities

USMA Civil and Mechanical Engineering Instructor Summer Workshop	2019
Participation in various conferences (ASCE, TRB, UHPC, etc)	2016-Present

1. Name

John Adam Pegues — Department of Civil and Mechanical Engineering

2. Education

Master of Business Administration, Darden Graduate School of Business (U.Va.)	2014
Master of Science, Civil Engineering, University of Virginia	2005
Bachelor of Science, Ocean Engineering, United States Naval Academy	2003

3. Academic experience

Instructor, USMA (FT)	2019 – present

4. Non-academic experience

Graduate Research Engineer, Virginia Transportation Research Council	2003 - 2005
Naval aviator, United States Navy	2005 - 2015
Project Manager, Office of Naval Research	2015 - 2018

5. Certifications or professional registrations

Engineer in Training, MD	2003

6. Current membership in professional organizations

7. Honors and awards

Distinguished Graduate, United States Naval Academy	2003
Military Volunteer Outstanding Service Medal	2003
Society of the Cincinnati Prize	2003
Dean's Fellow, University of Virginia	2003 - 2005
Air Medal	2010
Navy Achievement Medal	2011
Navy Commendation Medal	2017

8. Service activities

Institutional Service:

Assistant Officer in Charge, Marathon Team	2018 - present
Officer Representative, Varsity Baseball	2018 – present
Assistant Officer in Charge, Aviation Club	2018 - present

9. Most important publications and presentations from the past five years

10. Most recent professional development activities

1. Name

Rahul Verma — Department of Civil and Mechanical Engineering

2. Education

Master of Science, Agricultural Engineering, Texas A&M University 1999
Bachelor of Engineering, Environmental Engineering, Michigan Technological University 1996

3. Academic experience

Assistant Professor and CIE Associate Director, USMA (FT) 2015 - Present
Adjunct Faculty (PT) 2015

4. Non-academic experience

Verma Engineering & Consulting, Principal Engineer 2007- Present
East of Hudson Watershed Corporation, Executive Director 2012- 2014
USMA, Directorate of Public Works, Environmental Engineer 2009- 2011
Kleinfelder, Senior Civil Engineer 2006- 2008

5. Certifications or professional registrations

Professional Engineer, NY 2005

6. Current membership in professional organization

American Society of Civil Engineers (ASCE)
American Society of Engineering Education (ASEE)

7. Honors and awards

ASCE 2011 Outstanding Service Project Award- Jennifer Turner Project 2011

8. Service activities

Institutional Service:

C&ME Summer Leadership Experience, USMA 2015 - present
Officer in Charge, CME Engineering Club, USMA 2015 - present
Officer in Charge, Women's NCAA Volleyball Team 2017 - present

Professional Service:

American Society of Civil Engineers, Mid-Hudson Branch- Board Member 2005-Present
Cornwall Central High School- E-Day STEM event coordinator 2007-Present
Hudson River Watershed Alliance, Board Member 2013-2016

9. Most important publications and presentations from the past five years

Conference Proceedings:

Biering, C. Hanus, J. and Verma, R, (2016) "Teaching Contract Disputes in Construction Management, ASEE 2016 Annual Conference and Exposition (co-listed below in "Presentations").

Presentations:

Biering, C. Hanus, J. and Verma, R, (2016) "Teaching Contract Disputes in Construction Management, ASEE 2016 Annual Conference and Exposition

Verma, R., (2015, 2012) "Moving Watershed Management into The Watershed", 2015 NEWWA Water Resources & Sustainability Symposium; 2012 IECA & LHCCD Annual Conference.

Verma, R., (2014) "Implementing a Watershed Management Program", 2014 NYWEA Watershed Science and Technical Conference

.

10. Most recent professional development activities

2018 Greenbuild International Conference and Expo, Attendee
2018 ASCE National Convention, Attendee
2019 West Point Summer Leadership Experience, CE Division Lead

1. Name

Brad William Wambeke — Department of Civil and Mechanical Engineering

2. Education

Doctor of Philosophy, Civil Engineering, North Carolina State University	2011
Master of Science, Civil Engineering, University of Minnesota	2003
Master of Science, Engineering Management, Missouri Science and Technology	1998
Bachelor of Science, Civil Engineering, South Dakota State University	1993

3. Academic experience

Civil Engineering Division Director, USMA (FT)	2017 - present
Civil Engineering Design Group Director, USMA (FT)	2014 - 2017
Associate Professor, USMA (FT)	2018 - present
Assistant Professor, USMA (FT)	2014 - 2018
Assistant Professor, USMA (FT)	2004 – 2005
Instructor, USMA (FT)	2003 – 2004

4. Non-academic experience

Battalion Commander, Fort Carson, CO and Kandahar, Afghanistan	2012 - 2014
Task Force Operations Officer, Fort Bragg, NC and Camp Taji, Iraq	2007 - 2008
Task Force Executive Officer, Fort Bragg, NC and Camp Speicher, Iraq	2006 - 2007
Company Commander, Fort Bragg, NC	1999 – 2001

5. Certifications or professional registrations

Licensed Professional Engineer, MO (E-29437)	1998

6. Current membership in professional organization

American Society of Civil Engineers (ASCE); American Society for Engineering Education (ASEE); Society of American Military Engineers (SAME); Lean Construction Institute (LCI); Tau Beta Pi; Chi Epsilon; Phi Kappa Phi

7. Honors and awards

Dean’s Award for Service and Cadet Development Excellence	2017
Jared Mansfield Outstanding Teacher Award	2005
Society of American Military Engineers “Most Student Members” Award	2005
Distinguished Military Graduate, South Dakota State University	1993

Phi Kappa Phi Honor Society

Military: Bronze Star Medal (3); Meritorious Service Medal (4); Army Commendation Medal (2); Army Achievement Medal (3); National Defense Service Medal (2); Afghanistan Campaign Medal; Iraq Campaign Medal (2); Global War on Terror Service Medal; Korean Defense Service Medal; Army Service Ribbon; Overseas Service Medal (2); NATO Service Medal; Meritorious Unit Citation; Army Superior Unit Award; De Fleury Medal (Bronze)

8. Service activities

Institutional Service:

Director, Civil Engineering Division, D/C&ME	2017 - present

Officer in Charge, USMA Scoutmasters' Council	2016 - present
Design Group Director, Department of Civil and Mechanical Engineering,	2014 - 2017
Multiple civilian and military faculty search committees	2015 - present
USMA Curriculum Committee	2019
USMA Operational Experience Committee	2016
USMA Program STEM Goal Team	2014 - 2015
Company and Department Academic Counselor	2014 - present

Professional Service:

ABET Program Evaluator, ASCE	2017 - present
NCEES team for developing the Fundamentals of Engineering Exam	2017 - present
Mentor, ExCEEd Teaching Workshop	2014 - 2019
Reviewer for ASEE journal and conference manuscripts	2017 - present

9. Most important publications and presentations from the past five years

Wambeke, B. **W.,** Mainwaring, T., "Monitoring and Controlling a Construction Project in the Classroom," *2019 American Society for Engineering Education Annual Conference*, June 2019.

Wambeke, B. **W**., Barry, B. E., Bruhl, J. C., "Teaching Model as a Living Document," *2017 American Society for Engineering Education Annual Conference,* June 2017.

Hajifathalian, K., Howell, G, **Wambeke, B.,** and Hsiang, S. (2016). "Oops Simulation: Cost-Benefit Trade-Off Analysis of Reliable Planning for Construction Activities." *ASCE Journal of Construction Engineering and Management*, 142(8).

Biggerstaff P.E., A. O., & **Wambeke, B**. "Investigation of Probabilistic Multiple-Choice in a Structural Design Course," *2016 American Society for Engineering Education Annual Conference,* June 2016.

Stache, J. M., **Wambeke, B**., & Hanus, J. P. "Road Builders - Integrating Transportation and Construction Engineering." *2016 American Society for Engineering Education Annual Conference,* June 2016.

10. Most recent professional development activities

ABET Program Evaluator; Departmental faculty development workshops and new instructor seminars, USMA; ExCEEd Teaching Workshop mentor, West Point; NCEES Fundamental of Engineering Exam development; Design-Build capstone project faculty advisor; ASCE Education Summit and Department Head Conference; Participation and presentation at annual ASEE Conference.

1. Name

Rebecca Avrin Zifchock — Department of Civil and Mechanical Engineering

2. Education

Doctor of Philosophy, Biomechanics, University of Delaware 2007
Master of Science, Biomechanics, The Pennsylvania State University 2002
Bachelor of Science, Biological and Mechanical Engineering, Cornell University 2000

3. Academic experience

Dynamics Thread Leader, USMA (FT) 2018 - present
Associate Professor, USMA (FT) 2015 - present
Adjunct Lecturer, Baylor University (PT) 2017 - present
Assistant Professor, USMA (FT) 2010 - 2015
Postdoctoral Fellow, Hospital for Special Surgery (FT) 2007 - 2010
Adjunct Assistant Professor, Columbia University (PT) 2010

4. Non-academic experience

Visiting Researcher, US Army CCDC- Soldier Center (sabbatical) 2017 - 2018

5. Certifications or professional registrations

N/A

6. Current membership in professional organization

American Society of Biomechanics (ASB); International Society of Biomechanics (ISB).

7. Honors and awards

Finalist, C&ME Peter S. Michie Outstanding Teacher Award, USMA 2015
Advisor for 1st place team, Scott Clark Soldier Innovation Award, USMA 2014
Young Investigator Award, Gait and Clinical Movement Analysis Society 2002
Student Conference Award, Gait and Clinical Movement Analysis Society 2002

8. Service activities

Institutional Service:

Diversity Committee, USMA 2013 - present
Academic Research Council, Secretary, USMA 2019 - present
Head Department Academic Counselor 2019 - present
Officer Representative, Cadet Nordic Ski Club 2019 - present
Senior mentor and instructor, C&ME Instructor Summer Workshop, USMA 2012 - present
Civilian and faculty search committees 2016 - 2019
Committee Member, Institutional Review Board, USMA 2016 - 2018
West Point Leader Development System, Integration Committee, USMA 2014 - 2015

Professional Service:

Diversity Committee, American Society of Biomechanics 2018 - present
Abstract and Award Selection Committee, American Society of Biomechanics 2016 - present

Award Selection Committee, Gait and Clinical Movement Analysis Society	2008 - 2012
Reviewer for various journal and conference manuscripts	2005 - present

9. Most important publications and presentations from the past five years

Panizzolo, FA, Freisinger, GM, Karavas, N, Eckert-Erdheim, AM, Siviy, C, Long, A, **Zifchock, RA**, LaFiandra, ME, Walsh, CJ (2019) "Metabolic Cost Adaptations During Training with a Soft Exosuit Assisting the Hip Joint" *Scientific Reports, Nature*, Vol 9(1), p. 9779.

Brown, A, Song, J, **Zifchock, R**, Lehhoff, M, Hillstrom, H. (2019) "Hip Muscle Response to a Fatiguing Run in Females with Iliotibial Band Syndrome" *Human Movement Science*, Vol 64, p. 181-190.

Zifchock, R, Parker, R, Wan, W, Neary, M, Song, J, Hillstrom, H. (2019) "The Relationship Between Foot Arch Flexibility and Medial-Lateral Ground Reaction Force Distribution" *Gait and Posture*, Vol 69, p. 46-49.

Song, J, Choe, K, Neary, M, **Zifchock, R**, Cameron, K, Trepal, M, Hannan, M, Hillstrom, H. (2018) "Comprehensive Biomechanical Characterization of Feet in USMA Cadets: Comparison across Race, Gender, Arch Flexibility, and Foot Types" *Gait and Posture*, Vol 60, p. 175-180.

Zifchock, R, Sulley, M, Helton, G, Freisinger, G, Blackmon, W, Wilson, R, Goss, D. (2017) "Quantification of Torsional Stiffness in Running Footwear: Proposed Methodology" *Journal of Footwear Science*, Vol 9(3), p. 121-126.

Zifchock, R, Theriot, C, Hillstrom, H, Song, J, Neary, M. (2017) "The Relationship between Arch Height and Arch Flexibility: A Proposed Arch Flexibility Classification System for the Description of Multi-Dimensional Foot Structure" *Journal of the American Podiatric Medical Association*, Vol 107(2), p. 119-123.

Brown, A, **Zifchock, R**, Hillstrom, H, Song, J, Tucker, C. (2016) "The Effects of Fatigue on Lower Extremity Kinematics, Kinetics, and Joint Coupling in Symptomatic Female Runners with Iliotibial Band Syndrome" *Clinical Biomechanics*, Vol 39, p. 84-90.

10. Most recent professional development activities

Departmental faculty development workshops and new instructor seminars, USMA; Product research, design and development, US Army Combat Capabilities Development Center, Natick, MA; Participation and presentation in various conferences

1. Name
Ozer A. Arnas Department of Civil and Mechanical Engineering

2. Education
Doctor of Philosophy, Mechanical Engineering, North Carolina State 1964
Master of Science, Mechanical Engineering, Duke University 1961
Bachelor of Engineering, Mechanical Engineering, Robert College, Istanbul 1958

3. Academic experience
Visiting Professor, Department of Heat Transfer and Flow Engineering, Abo Akademi University, Turku, Finland, Sabbatical May-June 2014
Visiting Professor, Department of Mechanical Engineering, Polytechnic, University of Sao Paolo, Brazil, Sabbatical February-March 2014
Adjunct Professor, Department of Mechanical Engineering, CSU-Sacramento, Sabbatical September 2006 - May 2007
Visiting Professor, Department of Energy Engineering, University of Padua, Italy, Sabbatical February - April 2007
Professor Emeritus, Louisiana State University 1986 - PRESENT
Professor, Department of Civil and Mechanical Engineering
United States Military Academy at West Point 1998-PRESENT
Visiting Professor, Mechanical Engineering Department
Boğaziçi University, Istanbul 1996-1998
Professor, Mechanical Engineering Department
San Jose State University, **Retired** 1989-December 1992
Professor, Mechanical Engineering Department, CSU-Sacramento 1987 - 1989
Professor, Mechanical Engineering Department, CSU - Chico 1986 - 1987
Distinguished Faculty Fellow, Louisiana State University Foundation 1984 - 1985
Visiting Professor and Research Fellow, Institute of Thermodynamics
University of LIEGE, Belgium, Sabbatical 1979 - 1980
Visiting Research Professor, Institute of Heat Technology
EINDHOVEN University of Technology, the Netherlands, Sabbatical 1979 - 1980
Visiting Professor, University of LIEGE, Belgium, Sabbatical 1972 - 1973
Assistant Professor, Associate Professor, Professor, Louisiana State University 1962 - 1986

4. Non-academic experience
NORCUS Research Professor, Battelle Pacific Northwest Division June-August 1992

5. Certifications or professional registrations
Professional Engineer, Louisiana, ME #9154, (INACTIVE)

6. Current membership in professional organization
LIFE FELLOW, ASME
LIFE MEMBER, ASEE
Pi Tau Sigma – Mechanical Engineering Honorary
Tau Beta Pi – Engineering Honorary.
Sigma Xi – Research Honorary

7. Honors and awards

Received Outstanding Civilian Service Medal - United States Army, United States Military Academy, West Point, NY, June 2001.

Received Commander's Award for Public Service Medal - United States Army, United States Military Academy, West Point, NY, May 2008.

LIFE FELLOW, American Society of Mechanical Engineers, ASME August 2002

WHO'S WHO in Science and Engineering 2005-2006.

LIFE MEMBER, American Society for Engineering Education, ASEE 2008.

Received a Certificate of Appreciation for 50 years of Full-time Teaching, United States Military Academy at West Point August 14, 2012

HONORARY CHAIR and Member, Advisory Committee

International Symposium on *Efficiency, Costs, Optimization and Simulation of Energy Systems*, ECOS 2015, Pau, France 30 June-3 July 2015

8. Service activities

ABET Visitor, appointed by ASME Council on Education, for accreditation of Mechanical Engineering Programs, 1989-1995

Member, Fundamentals in Engineering Examination and Its Minimum Passing Score Committee, National Council of Examiners for Engineering and Surveying, Clemson, SC, 1996

ASME-Fellows Review Committee 2010-2016

Technical Editor-ASME, *Journal of Energy Resources Technology* 1985-1996

Technical Editor-in-Chief, *International Journal of Applied Thermodynamics* 1998-2002

9. Most important publications and presentations from the past five years

Education-Teaching Teachers to Teach-Thermodynamics, Proceedings, 12th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics, HEFAT 2016, Malaga, Spain, July 11-13, 2016.

Exergy and Sustainability, Proceedings, 2nd International Conference on Viable Energy Trends, InVEnT-2017, Helsinki, Finland, 28-30 April 2017.

Teaching EXERGY Thermodynamics**, Proceedings**, International Symposium on *Efficiency, Costs, Optimization and Simulation of Energy Systems*, ECOS-2018, In Memoria to Prof. J. Szargut. Guimaraes, Portugal, June 17-23, 2018.

Is TEACHING a Bad Word, EDULEARN-2018, Palma de Majorca, Spain, July 2-4, 2018.

The Importance of Materials Science in Mechanical Engineering, ICMSR-2018, Frankfurt, Germany, September 26-28, 2018.

The Effect of Humidity on the Exergy Efficiency of Domestic Heat Pumps, ECOS 2019, Wroclaw, Poland, June 23-28, 2019.

10. Most recent professional development activities

Participation and presentation in various conferences

1. Name
Andrew Thomas Bellocchio Department of Civil and Mechanical Engineering

2. Education

Doctor of Philosophy, Aerospace Engineering, Georgia Institute of Technology	2018
Master of Science, Aerospace Engineering, Georgia Institute of Technology	2005
Bachelor of Science, Mechanical Engineering, United States Military Academy	1997

3. Academic experience

Thermal-Fluids Thread Leader, USMA (FT)	2018 - present
Assistant Professor, USMA (FT)	2018 - present
Assistant Professor, USMA (FT)	2008-2009
Engineering Education Advisor, National Military Academy of Afghanistan (FT)	2008
Instructor, USMA (FT)	2006-2008

4. Non-academic experience

Operations Officer, 116th Military Intelligence Brigade (Aerial)	2013 - 2015
Operations Officer, Task Force ODIN-Enhanced, Afghanistan	2012 - 2013
Chief, Military Transition Team, 1st Infantry Division, Iraq	2009 - 2010
Company Commander, Headquarters Company 2d Aviation Brigade, Korea	2002 - 2003
Air Traffic Control Company Executive Officer, 10th Combat Aviation Brigade	2000 - 2001
Assault Helicopter Platoon Leader, 10th Combat Aviation Brigade	1998 - 2000

5. Certifications or professional registrations

FAA Licensed Commercial Pilot (rotary, fixed wing, instruments)	2010
Professional Engineer, Virginia	2009
Senior Army Aviator	2009
Advanced Military Transition Team Training	2009
Army Aviator	1998
Engineer in Training, New York	1997

6. Current membership in professional organization
American Society of Mechanical Engineers (ASME); Vertical Flight Society (VFS), Army Aviation Association of America (AAAA)

7. Honors and awards

Team Captain, 2nd place in Vertical Flight Society Student Design Competition	2017
Finalist, 2014 Intelligence and Security Command Officer of the Year	2015
Military awards to include 2 Bronze Stars	2013, 2010
Distinguished Cadet, USMA	1996-1997
Dean’s List, USMA	1994-1997

8. Service activities
Institutional Service:

Coach, Leader Challenge	2019
Platoon Trainer, Cadet Leadership Development Training	2019

Civilian faculty search committees	2019 - present
Member, Creativity and Critical Thinking Assessments Committee	2018 - present
Officer Representative, Army Baseball	2018 - present

Professional Service:

Treasurer, West Point Chapter of AAAA	2019 - present
Reviewer for various journal and conference manuscripts	2018 - present

9. Most important publications and presentations from the past five years

Villandre, T., Schuette, T., Carrillo, D., **Bellocchio, A.**, McDonald, K., (2019), "Structural Health Monitoring," *Poster session in the 2019 DoD Allied Nations Technical Corrosion Conference*, Oklahoma City, OK, August 12-15.

Bellocchio, A., Benson, M., Van Poppel, B., Norberg, S., Benz, R. (2019), "An Enhanced Gas Turbine Engine Laboratory: A Learning Platform Supporting an Undergraduate Engineering Program," *Proceedings of the American Society of Mechanical Engineers 2019 Turbo Machinery Technical Conference*, Phoenix, AZ, June 17-21, GT2019-91616.

Bass, J., Bouchard, E., **Bellocchio, A.**, Courtois, N., Lacerda, M., Marois, F., Mehanovic, D., Murphy, A., Peloquin, R., Schrage, D., Rancourt, D., (2019), "Preliminary Design of a Highly Efficient VTOL System Based on Tethered Fixed-Wing Aircraft," *Proceedings of the 75th Annual Forum of the Vertical Flight Society*, Philadelphia, PA, May 13-16, 75_2019_0023_Bass.

Beigh., M., **Bellocchio, A.**, (2018), "Analysis of a Maintenance Free Operating Period Sustainment Strategy for Future Vertical Lift Family of Systems," U.S. Army Technical Report.

Bellocchio, A., (2018), "A Framework to Enable Rotorcraft Maintenance Free Operating Periods," PhD dissertation, Georgia Institute of Technology.

10. Most recent professional development activities

Technical Advisor for U.S. Army CCDC AvMC Aviation Development Directorate, Speaker to the 2019 Future Sustainment Concept Synthesis, Departmental faculty development workshops and new instructor seminars, Peer reviewer for ASME International Gas Turbine Expo, Lecturer at Mounger Writing Center's Technical Communication Workshop (USMA).

1. Name

Frederick Todd Davidson — Department of Civil and Mechanical Engineering

2. Education

Doctor of Philosophy, Mechanical Engineering, University of Texas at Austin	2012
Master of Science, Mechanical Engineering, University of Texas at Austin	2008
Bachelor of Science, Engineering Science, Trinity University	2005

3. Academic experience

Assistant Professor of Mechanical Engineering, USMA (FT)	2019 – present
Associate Director, Center for Innovation and Engineering, USMA (FT)	2019 – present
Research Associate, Energy Institute, University of Texas at Austin (PT)	2016 – present
Research Associate, Mechanical Engineering, University of Texas at Austin (PT)	2015 – present
Lecturer, University of Texas at Austin (FT)	2015 – 2019
Postdoctoral Fellow, University of Texas at Austin (FT)	2014 – 2015

4. Non-academic experience

Chief Executive Officer & Founder, nCarbon Inc.	2012 – 2014
Engineer, nCarbon Inc.	2012 – 2014
Systems Engineer II, Raytheon Missile Systems	2007 – 2010
Systems Engineer I, Raytheon Missile Systems	2002 – 2007

5. Certifications or professional registrations

Six Sigma Specialist (Raytheon Company)

6. Current membership in professional organization

American Society of Mechanical Engineers (ASME); American Association for the Advancement of Science (AAAS).

7. Honors and awards

Global Finalist – *1776 Challenge Cup*	2014
Most Promising – Top Honors at *Rice Energy Venture Forum*	2013
Best Paper Award – ASME International Gas Turbine Institute	2012
Young Engineer Travel Award – ASME International Gas Turbine Institute	2012
SM-3 Blk IIA Individual Achievement Award, Raytheon Company	2009
Advanced Study Program Award, Raytheon Company	2006 – 2008
EKV Team Award, Raytheon Company	2006
Presidential Scholar Award, Trinity University	2001 – 2005

8. Service activities

Institutional Service:

Officer Representative, Men's Soccer, USMA	2019 – present
PhD Committee Member & Advisor for numerous graduate students, UT Austin	2014 – present

Professional Service:

Judge & Moderator for various conference panels and student competitions	2018 – present
Co-Chair, Film Cooling Session, ASME *Turbo Expo*	2011

Reviewer for various journal and conference manuscripts 2010 - present

9. Most important publications and presentations from the past five years

Nagasawa, K., **Davidson, F.T.**, Lloyd, A.C., Webber, M.E., "Impacts of renewable hydrogen production from wind energy in electricity markets on potential hydrogen demand for light-duty vehicles", *Applied Energy*, Vol. 253, pp. 1001-1016, (February 1, 2019)

Johnson, S.C., **Davidson, F.T.**, Rhodes, J.D., et al. Chapter 5 - Selecting Favorable Energy Storage Technologies for Nuclear Power, Storage and Hybridization of Nuclear Energy – Techno-economic Integration of Renewable and Nuclear Energy, Academic Press, Elsevier, ISBN 978-0-12-813975-2, 2019

Alexandratos, S.D., Barak, N., Bauer, D., **Davidson, F.T.**, et al. "Sustaining Water Resources: Environmental and Economic Impact", *ACS Sustainable Chemistry & Engineering*, 7 (3), pp 2879-2888 (January 23, 2019) DOI: 10.1021/acssuschemeng.8b05859

Aminfard, S., **Davidson, F.T.**, Webber, M.E., "Multi-layered Spatial Methodology for Assessing the Technical and Economic Viability of Using Renewable Energy to Power Brackish Groundwater Desalination", *Desalination*, Vol. 450, pp. 12-20, (January 15, 2019)

Glazer, Y.R., **Davidson, F.T.**, Lee, J.J., Webber, M.E., "An Inventory of the Technical Potential to use Flare Gas for Onsite Treatment of Hydraulic Fracturing Wastewater", *Current Sustainable/Renewable Energy Reports*, 4:219-231, (October 30, 2017)

Davidson, F.T., Nagasawa, K., Webber, M.E., "The Rise of Electrofuels", *Mechanical Engineering*, ASME, September 2017

Belmont, E., **Davidson, F.T.**, Glazer, Y.R., Beagle, E., Webber, M.E., "Accounting for Water Formation from Hydrocarbon Fuel Combustion in Life Cycle Analyses", *Environmental Research Letters*, Vol. 12, No. 9, (September 19, 2017)

Beal, C.M., **Davidson, F.T.**, Webber, M.E., Quinn, J.C., "Flare Gas Recovery for Algal Protein Production", *Algal Research*, 2016

Cook M.A., King, C.W., **Davidson, F.T.**, and Webber, M.E., "Assessing the Impacts of Droughts and Heat Waves at Thermoelectric Power Plants in the United States Using Integrated Regression, Thermodynamic, and Climate Models." *Energy Reports.* 193-203 (2015)

Davidson, F.T., Kistenmacher, D.A., Bogard, D.G., "A Study of Deposition on a Turbine Vane with a Thermal Barrier Coating and Various Film Cooling Geometries", *Journal of Turbomachinery*, 136(4), 041009 (April 4, 2014)

Davidson, F.T., Kistenmacher, D.A., Bogard, D.G., "Film Cooling with a Thermal Barrier Coating: Round Holes, Craters, and Trenches", *Journal of Turbomachinery*, 136(4), 041007 (April 4, 2014).

10. Most recent professional development activities

Invited presentations: *Conference on Transportation Economics, Energy, and the Environment*; *Austin Electricity Conference*; *Energy System Integration Group – Spring Workshop* ; *IEEE Conference on Intelligent Transportation Systems* ; *ACS National Meeting*

Lead investigator for funded projects with ExxonMobil and Department of Energy

1. Name

Carolann Koleci Department of Civil and Mechanical Engineering

2. Education

Doctor of Philosophy, Physics Education, Brown University
Master of Science, Mechanical Engineering, Brown University
Master of Science, Physics, Brown University
Bachelor of Science, Physics, *Summa Cum Laude*, University at Albany, State University of New York

3. Academic experience

Assistant Professor of Mechanical Engineering, USMA 2017 - present
Associate Director, Center for Innovation and Engineering, USMA 2017 - present
Assistant Professor of Physics, USMA 2015 - 2017
Teaching Faculty, School of Engineering and Applied Sciences, Harvard 2012 - 2015
Visiting Assistant Professor of Physics, College of the Holy Cross 2011 - 2012
Director of Physics Education, Worcester Polytechnic Institute 2008 - 2011
Assistant Professor of Physics, Worcester Polytechnic Institute 2002 - 2008
Adjunct Assistant Professor of Physics, Worcester Polytechnic Institute 2001 - 2002

4. Non-academic experience

Service Account Approval Authority, High Performance Computing 2017 - present
Albany Running Exchange, Member 2018 -
present Hudson Mohawk Road Runners Club, Member 2018 -
present International Clarinet Association

5. Certifications or professional registrations

Phi Beta Kappa

6. Current membership in professional organization

American Association of Physics Teachers, American Physical Society

7. Honors and awards

West Point Medal for Civilian Service, Department of Physics 2017
Starr Family Advising Award, Harvard University, Finalist 2015
Levenson Teaching Award, Harvard University, Finalist 2015
Harvard University, Bok Certificate of Teaching Excellence 2013- 2015
WPI Trustees Award for Outstanding Academic Advising
2006
Alpha Phi Omega, Excellence in Service to WPI 2005
Sigma Xi, Research Honor Society 2001
Brown University President's Award for Excellence in Teaching, Finalist
2001 Barry Goldwater Scholar

8. Service activities

Institutional Service:

Campus Co-Representative for Barry Goldwater Scholarship Program	2017 - present
High Performance Computing Seminars Coordinator	2017 - present
Summer Leaders Experience, co-Chair	2017 - present
STEM Outreach Program in Physics	2015 - 2017
Mentor and teaching evaluator, C&ME Instructor Summer Workshop, USMA	2019 - present

Professional Service:

Journal Reviewer, Phys Rev, Special Topics, Physics Education	2002 - 2015
National Science Foundation, External Reviewer	2015 - 2017
Women In Science and Engineering, Brown University	2001- present
Reviewer for various journal and conference manuscripts	2002 - present

9. Most important publications and presentations from the past six years

Gerving, C., Halverson, T., Haseman, M., **Koleci, C.** (2017), "Redesign of An Introductory Physics Laboratory Program," *American Association of Physics Teachers Conference*, Atlanta, GA, Winter Meeting.

Gerving, C., Haseman, M., Gillick, A., **Koleci, C.** (2017), "Constructing Teams to Maximize Productivity and Enhance Conceptual Understanding," *American Association of Physics Teachers Conference*, Atlanta, GA, Winter Meeting.

Koleci, C. (2017), "Project-based and Team-based Learning in Introductory Physics," *Invited Talk*, Georgia Tech, Department of Physics.

Koleci, C. (2014), "Project-based and Team-based Learning," *American Association of Physics Teachers Conference*, Orlando, FL, Winter Meeting.

Koleci, C. (2013) "Team-based and Project-based Learning in a Flipped Introductory Physics Classroom," *American Association of Physics Teachers Conference*, Portland, Oregon, Summer Meeting.

Yoo, J., Mazur, E., Miller, K., **Koleci, C.**, Tucker, L., and Lukoff, B. (2013), "Teamwork and Communication Structures in Team-based Assessments," *International Conference on Physics Education*, Prague, Czech Republic, August 5-9.

10. Most recent professional development activities

NSF External Program Reviewer for Tennessee Tech, Department of Physics; contributed education talks at USMA, Department of Physics and Department of Civil and Mechanical Engineering; Led Annual Service Account Approval Authority Conference for the High Performance Computing and Modernization Program; Product research, design and development, US Army Combat Capabilities Development Center, Soldier Center (Natick, MA); Barry Goldwater Scholarship Lead Contact and Reviewer of internal application materials, including design of web-based application and evaluation tools; Participation and presentation at various conferences

1. Name

Richard V. Melnyk — Department of Civil and Mechanical Engineering

2. Education

Doctor of Philosophy, Aerospace Engineering, Georgia Institute of Technology	2013
Master of Science, Aerospace Engineering, Georgia Institute of Technology	2003
Bachelor of Engineering, Mechanical Engineering, United States Military Academy	1995

3. Academic experience

Mechanical Engineering Program Director, USMA (FT)	2017 - present
Associate Professor, USMA (FT)	2018 - present
Aerospace Thread Leader, USMA (FT)	2015 - present
Assistant Professor, USMA (FT)	2015 - 2017
Assistant Professor, USMA (FT)	2006 - 2007
Instructor, USMA (FT)	2004 – 2006

4. Non-academic experience

Visiting Researcher, Sandia National Laboratory (sabbatical)	2010 - 2011

5. Certifications or professional registrations

Professional Engineer, VA	2008
Engineer in Training, NY	1995

6. Current membership in professional organization

American Society of Mechanical Engineers (ASME); American Society for Engineering Education (ASEE); American Institute of Aeronautics and Astronautics, Army Aviation Association of America, American Helicopter Society

7. Honors and awards

Peter Michie Outstanding Teacher Award	2007
Distinguished Honor Graduate, Initial Entry Rotary Wing Course	1996
Phi Kappa Phi Honor Society	1995

8. Service activities

Institutional Service:

Director, Academic Flight Program	2018 - present
What Graduates Can do 5.4 Assessment Committee	2015 – present
Army Aviation Association of America Chapter President	2016 - present
Asst. Officer in Charge, Cadet Flying Team	2005 - present
Department Academic Counselor	2015 - present

Professional Service:

ABET Program Evaluator	2017 - present
Fundamentals of Engineering Exam Writing	2015 – present
Executive Member, Military Veterans Committee ASEE	2015 - 2017
Reviewer for various journal and conference manuscripts	2015 - present

9. Most important publications and presentations from the past five years

Melnyk, R.V. "Setting Certification Standards for Unmanned Aircraft Systems Control Links" presented at AIAA Scitech Conference, San Diego, CA January 7-11, 2019.

Melnyk, R.V., and Novoselich, B.J. "The Role of Andragogy in Mechanical Engineering Education", presented at the *2017 American Society for Engineering Education Conference*, Columbus, OH June 25-28, 2017.

Melnyk, R.V. "A Helicopter Flight Laboratory Experience in an Undergraduate Helicopter Aeronautics Course" presented at the *2017 American Society for Engineering Education Conference*, Columbus, OH June 25-28, 2017.

Melnyk R., Pafford, B., Brown, D., and Curriston, D. "West Point's Academic Flight Program" Army Aviation Association Magazine, August/September 2016 issue, 38-42.

Melnyk, R.V., Pyant. W.C., Boettner, D.D., and Brown, D.R. "Assessment of Implementing an Undergraduate Integrated Thermal-Fluids Course Sequence on the Results of the Fundamentals of Engineering Exam" presented at the 2016 American Society for Engineering Education Conference, New Orleans, LA June 25-30, 2016.

Melnyk, R.V., Schrage, D., Volovoi, V., Jimenez, H. "A Third-Party Casualty Risk Model for Unmanned Aircraft System Operations" *Reliability Engineering and System Safety Journal*, 124(2014) 105-116.

Melnyk, R.V., Schrage, D., Volovoi, V., Jimenez, H. Sense and Avoid Requirements for Unmanned Aircraft Systems Using a Target Level of Safety Approach" Risk Analysis Journal, DOI 10.1111 (2014).

10. Most recent professional development activities

ABET Program Evaluator; Departmental faculty development workshops and new instructor seminars, CFR 14 Part 107 certification; Developed Aeronautical Engineering minor; Developed new course ME201.

1. Name

Matthew Louis Miller — Department of Civil and Mechanical Engineering

2. Education

Master of Science, Aerospace Engineering, Georgia Institute of Technology	2016
Bachelor of Science, Mechanical Engineering, United States Military Academy	2007

3. Academic experience

Assistant Professor, USMA (FT)	2019 - 2020
Instructor, USMA (FT)	2017 - 2019

4. Non-academic experience

Brigade Assistant Operations Officer Air, Fort Riley, Kansas	2014-2015
Headquarters and Headquarters Troop Commander, Fort Riley, Kansas	2013-2014
Squadron Assistant Operations Officer, Fort Riley, Kansas	2012-2013
Squadron Intelligence Officer, Hunter Army Airfield, Georgia	2011-2012
Air Cavalry Platoon Leader, Hunter Army Airfield, Georgia	2009-2011

5. Certifications or professional registrations

None

6. Current membership in professional organization

American Society of Mechanical Engineers (ASME); American Society of Engineering Education (ASEE); Army Aviation Association of America (AAAA); West Point Association of Graduates (WPAOG); Phi Kappa Phi, Tau Beta Pi, Golden Key.

7. Honors and awards

Bronze Star Medal	2013
Distinguished Cadet Award, USMA	2005-2009
Dean's List, USMA	2005-2009

8. Service activities

Institutional Service:

Leader Challenge Platoon Mentor	2017 – present
Military Assistant, ExcEEd Teaching Workshop	2017
Department Academic Counselor	2017 – present
Aviation Branch Mentor	2017 – present

9. Most important publications and presentations from the past five years

Miller, M., Rigney, J., Arnold, D., Flaherty, D. (2019), "The Effects of Transitioning an Undergraduate Mechanical Engineering Course from Shorter and More Frequent Class Periods to Longer and Fewer In-Class Sessions," *2019 ASEE Annual Conference & Exposition*, Tampa Bay, FL, June, 25388.

Norberg, S., Ashcraft, T., **Miller, M.**, and Michael J. Benson. "Teaching Experimental Design in a Fluid Mechanics Course." *2018 ASEE Annual Conference & Exposition*, Salt Lake City, UT, June 3, 2018.

10. Most recent professional development activities

Intermediate Level Education (ILE) Distance Courses; Advisor, Fast Unmanned Aerial System (UAS) with MIT Lincoln Labs, 2019 – present; Advisor, Air Force Research Lab Service Academy Design Challenge, 2018-2019; Advisor, Aircraft Additive Manufacturing, 2017-2018; Advisor, Holston Ammunition Plant Cooling Upgrade, 2017-2018.

1. Name
Jeremy David Paquin — Department of Civil and Mechanical Engineering

2. Education

Master of Science, Aeronautics and Astronautics, Massachusetts Institute of Technology	2019
Master of Business Administration, Massachusetts Institute of Technology	2019
Bachelor of Science, Mechanical Engineering, United States Military Academy	2009

3. Academic experience

Instructor, USMA (FT)	2019 - 2020

4. Non-academic experience

Brigade Assistant Operations Officer, Fort Bliss, Texas	2016
Attack Reconnaissance Troop Commander, Fort Bliss, Texas	2015-2016
Assistant Brigade Aviation Officer, Fort Bliss, Texas	2014
Battalion Assistant Operations Officer, Illesheim, Germany	2013
Attack Platoon Leader, Illesheim, Germany	2011-2012

5. Certifications or professional registrations

Engineer in Training, NY	2009

6. Current membership in professional organization
American Society of Mechanical Engineers (ASME); American Society of Engineering Education (ASEE); Army Aviation Association of America (AAAA); American Institute of Aeronautics and Astronautics (AIAA); American Society of Thermal Fluids Engineers (AFTSE); Aircraft Owners and Pilots Association (AOPA); West Point Association of Graduates (WPAOG); Phi Kappa Phi, Tau Beta Pi, Golden Key.

7. Honors and awards

Bronze Star Medal	2016
Distinguished Honor Graduate, Aviation Captains Career Course	2014
Dennis H. Mahan Memorial Award, USMA	2009
Distinguished Cadet Award, USMA	2005-2009
Dean's List, USMA	2005-2009

8. Service activities
Institutional Service:

Leader Challenge Platoon Mentor	2019 – present
Department Technical Scholarship Team	2019 – present
Department Academic Counselor	2019 – present

9. Most important publications and presentations from the past five years
Paquin, J., Van Poppel, B., Bellocchio, A., Fisk, B., Ebner, L. Woodruff, J., Crow, D. (2019), "Undergraduate Internal Flow Pipe Friction Laboratory," *Proceedings of the American Society of Thermal Fluids Engineers (ASTFE) 4th Thermal and Fluids Engineering Conference*, New Orleans, LA, April 5-8, 3239087.

Paquin, J. (2019) “Methodology for Choosing a Contractor for the Apollo Spacecraft Command and Service Module,” *Proceedings of the American Institute of Aeronautics and Astronautics (AIAA) Science and Technology (SciTech) Conference*, Orlando, FL, January 6-10, TFEC-2020-31995.

Paquin, J. (2019), “A Systems-Based Analysis Method for Safety Design in Rocket Testing Controllers.” *Master's Thesis, Massachusetts Institute of Technology*, Cambridge, MA, June 9.

10. Most recent professional development activities

Master Teacher Program (1-year accelerated course); Intermediate Level Education (ILE) Distance Courses; Co-Advisor, Artillery-launched Unmanned Aerial System (UAS) with MIT Lincoln Labs, 2019 – present; Co-Advisor, Active Flow Control for Rotorcraft with NASA AMES, 2019 – present.

1. Name

Gunnar Olavi Tamm — Department of Civil and Mechanical Engineering

2. Education

Doctor of Philosophy, Mechanical Engineering, University of Florida	2003
Master of Science, Mechanical Engineering, Rutgers University	1998
Bachelor of Engineering, Mechanical Engineering, The Cooper Union	1996

3. Academic experience

Acting Deputy Department Head, USMA (FT)	2019 - 2020
Acting Mechanical Engineering Division Director, USMA (FT)	2018 - 2019
Distinguished Visiting Professor, US Air Force Academy (sabbatical)	2017 - 2018
Professor of Mechanical Engineering, USMA (FT)	2015 - present
Mechanical Engineering Program Director, USMA (FT)	2014 - 2017
Aero-Thermo Group Director, USMA (FT)	2011 - 2012
Associate Professor, USMA (FT)	2009 - 2015
Assistant Professor, USMA (FT)	2004 - 2009
Postdoctoral Associate, University of Florida (FT)	2003 - 2004

4. Non-academic experience

Visiting Researcher, Sandia National Laboratory (sabbatical)	2010 - 2011

5. Certifications or professional registrations

Engineer in Training, NY	2006

6. Current membership in professional organization

American Society of Mechanical Engineers (ASME); American Society for Engineering Education (ASEE); Society of American Military Engineers (SAME); American Solar Energy Society (ASES); Directed Energy Professional Society (DEPS); Tau Beta Pi.

7. Honors and awards

Adviser for 1st place team, Scott Clark Soldier Innovation Award, USMA	2019
Senior Instructor of the Semester, Dept of Engineering Mechanics, USAFA	2018
Meritorious Civilian Service Award, USMA	2015
Adviser for 1st place team, Rapid Equipping Force Grand Challenge, USMA	2012
Adviser for 1st place team, Soldier Design Competition, USMA/MIT	2009
C&ME Jared Mansfield Outstanding Teacher Award, USMA	2006
ASES John and Barbara Yellott Award (graduate research in solar energy)	2002
ASME Solar Energy Division Graduate Student Award	2002

8. Service activities

Institutional Service:

ABET Committee, US Air Force Academy	2017 - 2018
Chair, USMA ABET Committee	2015 - present
Multiple civilian and military faculty search committees	2015 - 2019
West Point Energy Council	2009 - present

Senior mentor and instructor, C&ME Instructor Summer Workshop, USMA	2009 - present
Officer in Charge, Cadet Ski Club	2005 - present
Company and Department Academic Counselor	2005 - present
Professional Service:	
ABET Advisory Board, The Cooper Union	2017 - 2018
ABET Program Evaluator	2013 - present
Associate Editor, Journal of Energy Resources Technology	2010 - 2016
Reviewer for various journal and conference manuscripts	2006 - present

9. Most important publications and presentations from the past five years

Benson, M., Ivanovsky, A., Cooper, M., **Tamm, G.**, Helmer, D., Van Poppel, B., and Fisk, B. (2019), "Experimental Study of a Turbulent Impinging Jet in an Undergraduate Heat Transfer Laboratory," *Proceedings of the American Society of Thermal Fluids Engineers (ASTFE) 4th Thermal and Fluids Engineering Conference*, Las Vegas, NV, April 14-17, TFEC-2019-27644.

Fisk, B., Van Poppel, B., Benson, M., **Tamm, G.**, Peters, A., and German, A. (2019), "Undergraduate Internal Flow Convection Heat Transfer Laboratory," *Proceedings of the American Society of Thermal Fluids Engineers (ASTFE) 4th Thermal and Fluids Engineering Conference*, Las Vegas, NV, April 14-17, TFEC-2019-27539.

Tamm, G., Jaluria, Y. (2017), "Flow of Hot Gases in Vertical Shafts with Natural and Forced Ventilation," *International Journal of Heat and Mass Transfer*, Vol. 114, Pp. 337-353.

Mauldin, D., O'Neill, L., De Mallie, I., Arnold, F., Florence, L. A., Hartke, J., Kashinski, D. O., Johnson, J. E., Lamb, J., Huffman, R., Riegner, D. E., Fell, N. F., Kreidler, T., **Tamm, G.** (2017), "Effects of Rotation and Inert Thermal Sinks on Laser Heating of Cold, Rolled-Steel Cylinders: Preliminary Experimental Results,' *Journal of Directed Energy*, Vol. 6, No. 2, Spring 2017, Pp. 198-208.

Siegel, N., **Tamm, G.** (2017) "Predictive Thermal Model for Phase Change within Steel Heated by Laser Energy," *Proceedings of the Directed Energy Modeling and Simulation Conference, 2017 Directed Energy Systems Symposium*, Huntsville, Alabama.

Geiser, K., Maier, W., Ives, N., Van Curen, J., **Tamm, G.**, Moore, H., and Hoyer, B. (2016), "Field Improvised Electric Arc Welder," *Proceedings of the 2016 ASME International Mechanical Engineering Congress and Exposition*, Phoenix, AZ, November 11-17, IMECE2016-67890.

Kreidler, T., **Tamm, G.**, Fell, N., Florence, L., Hartke, J., Kashinski, D. (2016), "Modeling the High Energy Laser Heating of a Rotating Target," *Proceedings of the Directed Energy Modeling and Simulation Conference, 2016 Directed Energy Systems Symposium*, Portsmouth, Virginia.

10. Most recent professional development activities

ABET Program Evaluator; Departmental faculty development workshops and new instructor seminars, USMA; SolidWorks and Arduino short courses, 1st Special Warfare Training Group, Ft. Bragg; Product research, design and development, US Army Combat Capabilities Development Center, Picatinny Arsenal; New Faculty Orientation, United States Air Force Academy; Participation and presentation in various conferences

1. Name
Kristopher Henry Otto Ahlers | Department of Mathematical Sciences

2. Education

Doctor of Philosophy, Mechanical Engineering, The University of Dayton,	2006
Master of Science, Mechanical Engineering, The University of Leeds,	2001
Bachelor of Science, Applied Physics, Pacific Lutheran University,	1996

3. Academic experience

Assistant Professor, USMA (FT)	2018 - present
Assistant Professor, USMA (FT)	2011 - 2014

4. Non-academic experience

Grants Officer, Air Force Office of Scientific Research, Tokyo, Japan,	2018
Branch Chief, 638th Electronic Systems Squadron, Hanscom AFB, MA,	2011
Engineering Consultant, 301st Intelligence Squadron, Misawa AFB, Japan	2009
Research Engineer, Air Force Research Laboratory, Dayton, OH,	2006
Systems Engineer, Lockheed Martin, UK,	2003
Platoon Leader, 501st Signal Company, ROK,	2001

5. Certifications or professional registrations
N/A

6. Current membership in professional organization
Pi Mu Epsilon

7. Honors and awards
Military: Defense Meritorious Service Medal (3), Meritorious Service Award, Joint Service Commendation Medal, Air Force Commendation Medal, Army Commendation Medal, Global War on Terror Expeditionary Medal, National Defense Medal

8. Service activities
Institutional Service:
Officer’s Representative, Women’s Basketball Team (2012-2014, 2018-present)
Professional Service:

International Program Review – Australia, lead planner and organizer	2018
International Program Review – Malaysia, lead planner and organizer	2017
International Program Review – Singapore, lead planner and organizer	2016
International Program Review – Malaysia, lead planner and organizer	2015
Ground Moving Target Symposium, lead planner and organizer	2009
Pacific Design Conference, lead planner and organizer	2007

9. Most important publications and presentations from the past five years

10. Most recent professional development activities
Completed institution two-year teacher development program

1. Name

Daniel Meadows	Department of Mathematical Sciences

2. Education

Master of Science, Applied Mathematics, Naval Postgraduate School	2017
Bachelor of Science, Quantitative Finance, University of Alabama	2007
Associate of Science, Lurleen B. Wallace Community College	2004

3. Academic experience

Course Director, United States Military Academy	2018 - Present
Instructor, United States Military Academy	2017 - 2018
Teaching Assistant, Naval Postgraduate School	2017

4. Non-academic experience

Company Commander, HHC USAG Vicenza	2014 - 2015
Operations Officer, USAG Vicenza	2012 - 2014
Deputy Disbursing Officer, Joint Task Force Bravo	2011 - 2012
Disbursing Agent, Forward Operating Base Kalsu, Iraq	2009 - 2010
Detachment Executive Officer, Deputy Disbursing Officer, Fort Carson, CO	2008 - 2009

5. Certifications or professional registrations

Operational Contracting	2012
Fiscal Law	2012
Planning Programming Budgeting & Execution	2012
Sexual Harassment / Assault Response and Prevention	2010
Unit Movement Officer	2008

6. Current membership in professional organization

Institute for Operations Research and the Management Sciences

7. Honors and awards

Meritorious Service Medal	2010, 2015
Overseas Service Ribbon	2010, 2011, 2015
Joint Service Commendation Medal	2011
Army Commendation Medal	2010
Airborne Badge	2008
National Defense Service Medal	2005
Global War on Terrorism Service Medal	2005
Army Service Ribbon	2005

8. Service activities

Institutional Service:

Cadet Sponsor	2017 - 2019
Department of Mathematics Historian	2017 - 2019
Annual Math Student Award Coordinator	2017 - 2019

Equal Opportunity Officer 2017 - 2019

Professional Service:

Grader for the Interdisciplinary Contest in Modeling (ICM) 2018 - 2019
Branch Mentor 2017 - 2019
Branch Representative 2017 - 2019
Battle Captain Mentor during Cadet Summer Training 2018

9. Most important publications and presentations from the past five years

Papers/Preprints:

Meadows, D. (2017) *Modeling the Operating Environment with Network Science*. Monterey, CA: Naval Postgraduate School, Department of Mathematics.

Presentations:

Meadows, D. (2019) *Graph Theory Applied to Building Modular Math Curriculum.* Institute for Operations Research and the Management Sciences (INFORMS), INFORMS Annual Meeting, Oct. 2019

10. Most recent professional development activities

Command and General Staff College Common Core, Redstone Arsenal, AL; Faculty Development Workshop 5, USMA

1. Name
Kristin M. Arney Department of Mathematical Sciences

2. Education
Doctorate in Philosophy (ABD), Operations Research, University of Washington
Master of Science, Operations Research, North Carolina State University, 2008
Bachelor of Science, Mathematical Sciences, Lafayette College, 1998

3. Academic experience
Six (USMA, Full Time, June 2008 - June 2011 and January 2017-present): Instructor (2008-2010); Assistant Professor (2010, 2017-present)

4. Non-academic experience

Intelligence Officer, 14th Combat Engineer Battalion, Fort Lewis, WA	1998-1999
Executive Officer and Collection Manager, 505th MI Battalion, Fort Lewis, WA	1999-2001
Intelligence Officer, 21st TSC, Kaiserslautern, Germany	2002-2004
Intelligence Officer and Company Cdr, 502nd MI Bn, Darmstadt, Germany	2004-2006
Brigade Intel Officer and Lead Planner, 593rd Sust Bde, JBL-McChord, WA	2011-2014

5. Current membership in professional organization
Mathematical Association of America (MAA), Military Operations Research Society (MORS)

6. Honors and awards

Distinguished Military Graduate	1998
George Wharton Pepper Prize, Lafayette College	1998
General Omar N. Bradley Research Fellowship in Mathematics	2007
Bronze Star Medal	
Meritorious Service Award (3)	
Army Commendation Medal (2)	
Army Achievement Medal (3)	

7. Service activities
Institutional Service:

Admissions Committee and Executive Committee	2017 - present
Advisory and Mentorship Assistance Committee	2018 - present
Academics 2052	2018 - present
Women's Soccer Officer Representative	2008-2011, 2017-present

Professional Service:
Interdisciplinary Contest in Modeling (ICM) Final Judge and Head Triage Judge for COMAP. Published in four COMAP journals focused on interdisciplinary modeling. COMAP UMAP Journals

9. Publications and presentations from the past five years
Books and Book Chapters:

Arney K. et al. (2020), "Developing the Cutting Edge of Assessment Techniques" in *Teaching and Learning the West Point Way*, IEEE eLearning Library, ISBN: 978-1-4244-6202-5, New York.

Journal Articles:

Arney, K. M., Blyman, K. K., Cepeda, J., Lynch, S., Prokos, M., &Warnke, S. (Abstract Accepted, Manuscript Under Review). Going beyond promoting: Preparing students to creatively solve future problems. Journal of Humanistic Mathematics - Creativity Special Issue.

Blyman, K. K., **Arney, K. M.**, Adams, B. E., & Hudson, T. (Abstract Accepted, Manuscript Under Review). Does your course effectively promote creativity?: Introducing the mathematical problem solving creativity rubric. Journal of Humanistic Mathematics - Creativity Special Issue.

Conference Proceedings:

Arney, K. M., Blyman, K. K. (2018). Transforming mathematics assessments to drive better learning. Presented at the Joint Mathematics Meetings, San Diego, CA.

Arney, K. M., Blyman, K. K., Bromberg, L., Lynch, S., Warnke, S., & Wattenberg, F. (2019). Assessment: From a silent killer of learning to an active driver of deeper learning. Mini-course presented at the Int'l Conference on Technology in Collegiate Mathematics, Scottsdale, AZ.

Blyman, K. K., Adams, B., **Arney, K. M.**, Bromberg, L., & del Cuadro-Zimmerman, D.A. (2019). Positive impacts of discovery learning assessments. Presented at the Joint Mathematics Meetings, Baltimore, MD.

Blyman, K. K., **Arney, K. M.** (2018). An alternate assessment technique - Evaluated. Presented at the Joint Mathematics Meetings, San Diego, CA.

Blyman, K. K., **Arney, K. M.**, and Bromberg, L. (2019). An experiment in assessing creativity and critical thinking in a freshman-level mathematical modeling course. Presented at the Joint Mathematics Meetings, Baltimore, MD.

Blyman, K. K., **Arney, K. M.**, and Warnke, S. D. (2019). Assessing modeling meaningfully in a freshmen-level mathematical modeling course through discovery learning assessments. Presented at the Joint Mathematics Meetings, Baltimore, MD.

Bromberg, L., Blyman, K., and **Arney, K.** (2018). Transforming mathematics assessments to drive better learning. Presented at MAA - MathFest, Denver, CO.

Wattenberg, F., Blyman, K., Bromberg, L., Harness, D., **Arney, K.**, Wohlberg, S., Warnke, S., and del Cuadro-Zimmerman, D. (2018). Assessment: From a silent killer of learning to an active booster of better learning. Mini-course presented at the International Conference on Technology in Collegiate Mathematics, Washington, DC.

10. Most recent professional development activities

1. Name

Daniel Bahaghighat Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

Ph.D., Chemistry, University of Washington, 2018
M.S., Chemistry, University of Washington, 2016
M.S., Chemistry, Missouri University of Science and Technology, 2008
B.A., Chemistry, Carson-Newman University, 2000

3. Academic experience – institution, rank, title, dates, full or part time

USMA, Instructor, 2008-2010
USMA, Assistant Professor, 2010-2011; 2018-

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Military Assignments: (all fulltime)
Guest Scientist, Defense Threat Reduction Agency, Los Alamos National Laboratory, Los Alamos, New Mexico (May 2012 – May 2015) Primary Focus: B61-12 Life Extension Program. Operation Officer, 4-6 Infantry, 3 Brigade 1st Armored Division, Al-Asad Air Base, Anbar Province, Iraq, Operation New Dawn (August 2011 – December 2011). Company Commander, One Station Unit Training (BCT/AIT), 82nd Chemical Battalion, Fort Leonard Wood, Missouri (August 2004 – June 2006). Brigade Force Modernization Officer, 1st Brigade 25th Infantry, Fort Lewis, Washington (November 2003 - March 2004). Platoon Leader, Chemical Reconnaissance, 2-14 Cavalry, 1st Brigade 25th Infantry, Fort Lewis, Washington (March 2002 – October 2003) RECON! Battalion Chemical Officer, 1-5 Infantry, 1st Brigade 25th Infantry, Fort Lewis, Washington (March 2001 – March 2002)

5. Certifications or professional registrations

Chemical Biological Radiological Nuclear Basic Officer Course; Airborne qualification; Air Assault qualification; Chemical Biological Radiological Nuclear Captains Career Course qualification; Intermediate Level Education qualification; Nuclear and Counter-proliferation Officer Course; Theater Nuclear Operations Course; Nuclear Policy Course.

6. Current membership in professional organization

American Chemical Society (ACS)

7. Honors and awards

Academic: Graduated with Honors, University of Washington
Military: Bronze Star Medal, Defense Meritorious Service Medal, Meritorious Service Medal, Army Commendation Medal (2), Army Achievement Medal, National Defense Service Medal, Iraq Campaign Medal, Global War on Terror Service Medal, Army Service Medal, Overseas Service Medal

8. Service activities (within and outside of the institution)

Institutional Service: Cadet Sponsorship Program; West Point ACS Chapter Assistant Officer-in-Charge; Army Hockey Team Officer Representative; Cadet Ski Patrol Officer Representative; Cadet Bass Fishing Club Officer Representative; Served as Department Building Commandant.

Professional Service: N/A.

9. Publications and presentations from the past five years

Derrick V. Gough, **H. Daniel Bahaghighat**, and Robert E. Synovec, “Column Selection Approach to Achieve a High Peak Capacity in Comprehensive Three-Dimensional Gas Chromatography”, *Talanta*, **2019**, 195, pp 822-829. https://doi.org/10.1016/j.talanta.2018.12.007

H. Daniel Bahaghighat, Chris E. Freye, and Robert E. Synovec, “Recent Advance in Modulator Technology for Comprehensive Two-Dimensional Gas Chromatography” *TrAC.*, **2019**, 113, pp 379-391. https://www.sciencedirect.com/science/article/pii/S0165993618301201?via%3Dihub

H. Daniel Bahaghighat, Chris E. Freye, Derrick V. Gough, and Robert E. Synovec, “Comprehensive two-dimensional gas chromatography and time-of-flight mass spectrometry detection with a 50 ms modulation period” *J. Chrom. A.*, **2018**, 1583, pp 117-123. https://doi.org/10.1016/j.chroma.2018.11.027

H. Daniel Bahaghighat, Chris E. Freye, Derrick V. Gough, Paige E. Sudol, and Robert E. Synovec Ultrafast Separations via Pulse Flow Valve Modulation to Enable High Peak Capacity Multidimensional Gas Chromatography” *J. Chrom. A.*, **2018**, 1573, pp 115-124. https://www.sciencedirect.com/science/article/pii/S0021967318309865

Chris E. Freye, **H. Daniel Bahaghighat**, and Robert E. Synovec, “Comprehensive Two-Dimensional Gas Chromatography using Partial Modulation via a Pulsed Flow Valve with a Short Modulation Period" *Talanta*, **2018**, 177, pp 142-149. https://www.ncbi.nlm.nih.gov/pubmed/29108568

Sarah E. Prebihalo, Kelsey L. Berrier, Chris E. Freye, **H. Daniel Bahaghighat**, Nicholas R. Moore, David K. Pinkerton, and Robert E. Synovec, “Multidimensional Gas Chromatography: Advances in Instrumentation, Chemometrics, and Applications” *Anal. Chem.*, **2018**, 90 (1), pp 505-532. https://pubs.acs.org/doi/pdf/10.1021/acs.analchem.7b04226

Nathanial E. Watson, **H. Daniel Bahaghighat**, Ke Cui, and Robert E. Synovec, “Comprehensive Three-Dimensional Gas Chromatography with Time-of-Flight Mass Spectrometry” *Anal. Chem.*, **2017**, 89 (3), pp 1793-1800. https://pubs.acs.org/doi/abs/10.1021/acs.analchem.6b04112

10. Most recent professional development activities.

Army Intermediate Level Education (2012).

1. Name
Cathleen Beth Barker Department of Physics and Nuclear Engineering

2. Education
Master of Science, Nuclear Engineering, University of Florida 2017
Bachelor of Science, Physics, United States Military Academy 2008

3. Academic experience
Course Director, USMA (PH205) 2019 –
Course Director, USMA (PH255) 2018 – 2018
Instructor, USMA (PH205) 2017 – 2018

4. Non-academic experience
NONE

5. Certifications or professional registrations
NONE

6. Current membership in professional organization
NONE

7. Honors and awards
Bronze Star Medal (1)
APGAR Award for Teaching Excellence 2019

8. Service activities
Institutional Service:
Officer Representative, Corps Squad Rifle Team, USMA 2018 -
PL300 Mentor, USMA 2017 -
Leader Challenge Facilitator, USMA 2017 -
New Instructor Training Leader, USMA 2019

9. Most important publications and presentations from the past five years
Cathleen Barker, Ting Zhu, Lucas Rolison, Scott Kiff, Kelly Jordan, and Andreas Enqvist. "Pulse Shape Analysis and Discrimination for Silicon-Photomultipliers in Helium-4 Gas Scintillation Neutron Detector." *EPJ Web Conferences*, 170 (January 2018). https://doi.org/10.1051/epjconf/201817007002.

Cathleen Barker, James Bowen, Andrew Wilhelm. "T21 and You: An Assessments Workshop for OpenStax Creator Fest," OpenStax Creator Fest 2019, Houston, Texas, April 2019.

Ting Zhu, Yinong Liang, Lucas Rolison, Cathleen Barker, Jason Lewis, Sasmit Gokhale, Rico Chandra, Scott Kiff, Heejun Chung, Heather Ray, James E. Baciak, Andreas Enqvist, Kelly A. Jordan. "Improved fission neutron energy discrimination with Helium-4 detectors through pulse filtering." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 848 (11 March 2017): 137-143.

10. Most recent professional development activities
New Instructor Training Course Director
ILE

1. Name
Kevin Cummiskey — Department of Mathematical Sciences

2. Education

Doctor of Philosophy, Biostatistics, Harvard University	2018
Master of Science, Computational Operations Research, College of William and Mary	2008
Bachelor of Science, Mathematics, West Point	2000

3. Academic experience

Associate Program Director, MA206 Intro to Probability/Statistics, West Point	2018 - 2019
Course Director, MA206 Intro to Probability/Statistics, West Point	2012 - 2013
Assistant Professor and Instructor, West Point	2010 - 2012

4. Non-academic experience

Operations Research and Systems Analyst, 2nd Infantry Division, South Korea	2013 - 2015
Military Officer, United States Army Engineer Branch	2000 - 2010

5. Certifications or professional registrations
Army-certified Data Scientist (Personnel Development Skill Identifier R1J)

6. Current membership in professional organization
American Statistical Association (ASA), ASA Section on Statistics and Data Science Education, ASA Section on Statistics in Defense and National Security, ASA Section on Health Policy Statistics, Pi Mu Epsilon.

7. Honors and awards

International Conference on Health Policy Statistics Best Paper Award	2017
Bradley Officer Research Fellowship in Mathematics	2017
Bradley Officer Research Fellowship in Mathematics	2016

8. Service activities
Institutional Service:

Executive Committee Member, West Point Writing Program	2018 - present
Cadet Character Development Discussant	2018 - present
Department Academic Counselor	2018 - present
Advises Assessment Study of West Point Writing Center Attendance	2019 - present
Advisor to West Point Smoking Cessation Working Group	2018 - present

Professional Service:

Advised Diversity Study for U.S. Army Corps of Engineers	2018 - 2019

9. Most important publications and presentations from the past five years
Baller, D., Thomas, D. M., **Cummiskey, K**., Bredlau, C., Schwartz, N., Orzechowski, K., ... & Salafia, C. M. (2019). Gestational growth trajectories derived from a dynamic fetal–placental scaling law. *Journal of the Royal Society Interface, 16*(159), 20190417.

Henneman, L. R., Choirat, C., Ivey, C., **Cummiskey, K.,** & Zigler, C. M. (2019). Characterizing population exposure to coal emissions sources in the United States using the HyADS model. *Atmospheric environment*, Vol. 203, pp. 271-280.

Cummiskey, K., Adams, B., Pleuss, J., Turner, D., Clark, N., Watts, K. (2019) Causal Inference in Introductory Statistics Courses. Under Review – *Journal of Statistics Education.*

Cummiskey, K., Adams, B., Pleuss, J., Turner, D., Clark, N., Watts, K. (2019) Causal Inference in Introductory Statistics Courses. *Presented at the Joint Statistical Meetings,* Denver, CO.

Cummiskey, K., Kim, C., Choirat, C., Henneman, L., Schwartz, J., Zigler, C. (2019) A Source-Oriented Approach to Coal-Combustion PM2.5 Health Effects. *Presented at the International Conference on Health Policy Statistics,* Charleston, SC.

Cummiskey, K., Kim, C., Choirat, C., Henneman, L., Zigler, C. (2018) A Data-Driven Approach to Source-Receptor Mapping of Power Plant Emissions to Exposed Populations. *Presented at the Joint Statistical Meetings,* Vancouver, Canada.

10. Most recent professional development activities

Advises numerous undergraduate research projects; Departmental faculty development workshops and new instructor seminars, USMA; Participation and presentation in various conferences

1. Name

Tanya T. Estes — Department of Electrical Engineering and Computer Science

2. Education

Doctor of Philosophy, Human-Centered Computing, Georgia Institute of Technology	2012
Master of Science, Computer Science, North Carolina State University	2004
Bachelor of Science, Mechanical Engineering, USMA	1995

3. Academic experience

Core Program Director, USMA	2019 – Present
Information Technology Program Director, USMA	2014 – 2019
Academy Professor, USMA	2014 – Present
Assistant Professor, USMA	2012 – 2014
Instructor, USMA	2004 – 2007

4. Non-academic experience

Military Officer, United States Army	1995 – present

5. Certifications or professional registrations

N/A

6. Current membership in professional organization

Association for Computing Machinery (ACM); Institute of Electrical and Electronics Engineers (IEEE); ACM Special Interest Group for Computer Science Education (SIGCSE); ACM Special Interest Group for Information Technology Education (SIGITE).

7. Honors and awards

Dr. Judith Resnik Scholarship	2004
Upsilon Pi Epsilon Honor Society	2003
Honor Graduate, Aviation Officer Basic Course	1996

8. Service activities

Institutional Service:

Officer in Charge, West Point Flying Team	2012 – present
Assistant Officer in Charge, West Point Ski Patrol	2012- present
Plebe Courses Committee	2019 – present
IT Program Steering Committee	2014 – 2019
Admissions Committee	2014 – 2016
Faculty Recruiting Officer	2005 – 2007
West Point Leadership Development Outcome Assessment Team Leader, IT	2014 – 2019

Professional Service:

N/A

9. Most important publications and presentations from the past five years

David Harvie, Jason Cody, Christopher Morrell, & **Tanya Estes**, "Using Virtual Machines to Enhance the Educational Experience in an Introductory Computing Course." in Proceedings of the 20th Annual SIG Conference on Information Technology Education (SIGITE '19). Tacoma, WA, USA, Oct. 19, pp 28-32.

David Harvie, **Tanya Estes**, and Lisa Shay, "Know your Role! Defining Faculty and External Stakeholder Roles in a Multidisciplinary Capstone Course." in Proceedings of the American Society for Engineering Education Annual Conference (ASEE '19). Tampa, FL, USA, Jun. 19.

Lisa Shay, **Tanya Estes**, David Harvie, "Reflection and Metacognition in Capstone Design." in Proceedings of the American Society for Engineering Education Annual Conference (ASEE '19). Tampa, FL, USA, Jun. 19.

David Harvie, **Tanya Estes**, and Michael Kranch. "Crafting a Foundation for Computing Majors." in Proceedings of the 19th Annual SIG Conference on Information Technology Education (SIGITE '18). Fort Lauderdale, FL, USA, Oct. 18, pp. 13-17.

David Harvie, Keith Major, and **Tanya Estes**, "Use of Commercial Online Training to Augment Programming Language Education." in Proceedings of the 19th Annual SIG Conference on Information Technology Education (SIGITE '18). Fort Lauderdale, FL, USA, Oct. 18, pp. 89-89.

Tanya Estes, James Finocchiaro, Jean Blair, Johnathan Robison, Justin Dalme, Michael Emana, Luke Jenkins, and Edward Sobiesk, "A Capstone Design Project for Teaching Cybersecurity to Non-technical Users." in Proceedings of the 17^{th} Annual Conference on Information Technology Education (SIGITE '16). Boston, MA, USA, Sep. 16, pp. 142-147.

Tanya Estes, Linda Mallory, and Edward Sobiesk, "The Value of a One Semester Exposure to the Institutional Review Board." in Journal for Computing Sciences in Colleges (CCSC). Clinton, NY, USA, Apr. 16. pp. 63-69.

Caitlyn Seim, **Tanya Estes**, Thad Starner, "Towards Passive Haptic Learning of Piano Songs" in Proceedings of IEEE World Haptics Conference. Chicago, IL, USA, Jun. 15. pp. 445-450.

Tanya Estes, Deborah Backus, and Thad Starner, "A Wearable Vibration Glove for Improving Hand Sensation in Persons with Spinal Cord Injury Using Passive Haptic Rehabilitation." in Pervasive Computing Technologies for Healthcare (PervasiveHealth). Istanbul, Turkey, May. 15. pp. 37-44.

10. Most recent professional development activities

Planned and executed the New Faculty Workshop for all inbound department faculty during the summer of 2019 for the Department of EECS, United States Military Academy. Served on committee developing the department's new Cyber major.

1. Name

Lee Alan Evans — Department of Mathematical Sciences

2. Education

Doctor of Philosophy, Industrial Engineering, University of Louisville	2018
Master of Science, Operations Research, Georgia Institute of Technology	2009
Bachelor of Science, Engineering Management, United States Military Academy	2000

3. Academic experience

Associate Program Director, USMA (FT)	2018 - present
Assistant Professor, USMA (FT)	2018 - present
Course Director, USMA (FT)	2018 - 2019
Assistant Professor, USMA (FT)	2011 - 2012
Assistant Course Director, USMA (FT)	2010 - 2011
Instructor, USMA (FT)	2009 - 2011

4. Non-academic experience

Operations Research and Systems Analysis Assignment Officer, Fort Knox, KY	2014 - 2015
Manpower Distribution Analyst, Fort Knox, KY	2012 - 2014
Company Commander, Fort Hood, TX / Taji, Iraq	2005 - 2007
Assistant Operations Officer, Fort Hood, TX	2005
Assistant Operations Officer, Fort Campbell, KY / Qayyarah, Iraq	2003 - 2004
Platoon Leader, Fort Campbell, KY / Qayyarah, Iraq	2001 - 2003

5. Certifications or professional registrations

Engineer in Training, NY	2000

6. Current membership in professional organization

Institute for Operations Research and Management Science (INFORMS); Military Operations Research Society (MORS); Alpha Pi Mu; Pi Mu Epsilon.

7. Honors and awards

University of Louisville Dean’s Citation	2018
University of Louisville Industrial Engineering Dissertation Award	2018
INFORMS Bonder Scholarship	2017
Omar Nelson Bradley Research Fellowship in Mathematics	2017
Omar Nelson Bradley Research Fellowship in Mathematics	2016
Meritorious Service Medal (3 Awards)	2015
Bronze Star Medal	2007
Air Medal (4 Awards)	2007
Senior Army Aviator Badge	2007
Air Assault Badge	1999

8. Service activities

Institutional Service:

Special Leader Development Program Mentor	2019 - present

Task Force Teamwork Department Representative	2019 - present
Women's Basketball Officer Representative	2019 - present
Department Security Manager	2018 - present
Baseball Officer Representative	2018 - present
Academic Advisor	2018 - present
Professional Service:	
INFORMS Annual Meeting Session Chair	2018 - present
Winter Simulation Conference Session Chair	2018 - present
INFORMS Student Chapter President	2016 - 2018
Reviewer for various journal and conference manuscripts	2018 - present

9. Most important publications and presentations from the past five years

Evans, L.A., Robinson, G.L. (Accepted 2019). "Evaluating our Evaluations: Recognizing and Avoiding Performance Evaluation Pitfalls." Military Review.

Evans, L.A., Bae, K.-HG. (2019). "U.S. Army Performance Appraisal Policy Analysis: A Simulation Optimization Approach." Journal of Defense Modeling and Simulation, Volume 16, Issue 2, pp. 191-205. Available at: https://doi.org/10.1177/1548512918787969.

Evans, L.A., Bae, K.-HG. (2018). "Simulation-based Analysis of a Forced Distribution Performance Appraisal System." Journal of Defense Analytics and Logistics, Volume 1, Issue 2, pp. 120-136. Available at: https://doi.org/10.1108/JDAL-10-2017-0022.

Evans, L.A., Bae, K.-H.G., Roy, A. (2017). "Single and Multi-Objective Parameter Estimation of a Military Personnel System via Simulation Optimization." Proceedings of the 2017 Winter Simulation Conference, edited by W. K. V. Chan, A. D'Ambrogio, G. Zacharewicz, N. Mustafee,
G. Wainer, and E. Page, Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc., pp. 4058-4069. Available at: https://doi.org/10.1109/WSC.2017.8248115.

Bae, K.-H.G., **Evans, L.A.**, Summers, A. (2016). "Lean Design and Analysis of a Milk-Run Delivery System." Proceedings of the 2016 Winter Simulation Conference, edited by T. M. K. Roeder, P. I. Frazier, R. Szechtman, E. Zhou, T. Huschka, and S. E. Chick, Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc., pp. 2855-2866. Available at: https://doi.org/10.1109/WSC.2016.7822321.

10. Most recent professional development activities

Departmental Faculty Development Workshop; Center for Faculty Development seminars; INFORMS Annual Meeting; Winter Simulation Conference; Reviewer for various journal and conference manuscripts

1. Name
Stanley F. Florkowski Department of Mathematical Sciences

2. Education

Doctor of Philosophy, Applied Mathematics, Lehigh University, PA	2017
Master of Science, Applied Mathematics, Naval Postgraduate School, CA	2008
Bachelor of Science, Systems Engineering, United States Military Academy, NY	1999

3. Academic experience

Advanced Mathematics Associate Program Director, USMA (FT)	2018 - present
Assistant Professor, USMA (FT)	2011, 2017 - present
Assistant Professor, USMA (FT)	2011, 2017 - present

4. Non-academic experience

Chief, US Capabilities Branch, J8 USFK, Yongsan, South Korea (FT)	2013 - 2014
Joint Capabilities Analyst, J8 USFK, Yongsan, South Korea (FT)	2012 - 2013
Brigade Assistant Logistics Officer, 205th MI BDE, Wiesbaden, Germany (FT)	2006
Company Commander, HHD, 205th MID BDE, Forward deployed to Iraq (FT)	2005 - 2006
Brigade Operations Officer, 205th MI BDE, Wiesbaden, Germany (FT)	2004 - 2005
Brigade Plans Officer, 205th MI BDE, Forward deployed to Iraq (FT)	2003 - 2004
Battalion Training Officer, 532nd MI BN, Yongsan, South Korea (FT)	2002
Company Executive Officer, HHSC, 532nd MI BN, Yongsan, South Korea (FT)	2001 - 2002
Battalion Intelligence Officer, 532nd MI BN, Yongsan, South Korea (FT)	2000 - 2001
Head Soccer Coach and PE Instructor, USMAPS, Fort Monmouth, NJ (FT)	1999

5. Certifications or professional registrations
USMA Center for Teaching Excellence: Master Teacher Program Certification 2011

6. Current membership in professional organization
NONE

7. Honors and awards
Warren Randolph Church Award for Excellence in Mathematics (Naval Postgrad School) 2009

8. Service activities
Institutional Service:
Department Computer Officer 2017 - present
Professional Service:
None

9. Most important publications and presentations from the past five years
S. Morse, B. Allen, **S. Florkowski** (2018) Modeling Population Ecology on Isle Royale. Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations.

S. Florkowski, S. Morse, B. Allen (2018). “The Moose and Wolves Project: Uniting Differential Equations and Vector Calculus”. MathFest, Interdisciplinary Modeling Session, Denver, CO.

Florkowski, S. (2017) "Extensions of the Hamiltonian Cycle/Path Problems," Theses and Dissertations, Lehigh University, Bethlehem, PA.

S. Florkowski, G. Isaak (2017) "Non-disjoint Path Covering Number of Threshold Graphs, 48th SE International Conference on Combinatorics", Graph Theory & Computing, FAU, Boca Raton, FL.

D. Arney, **S. Florkowski**, S. Wilkerson (2014) "A Simple Method for Dynamic Visualization of Differential Equations", Journal of Math and Computer Ed., Vol. 48, No. 2.

10. Most recent professional development activities

Associate Program Director for MA153; SIMIODE Faculty Development Workshop; D/Math New Faculty Training, USMA.

1. Name
David Woodruff Hutchinson Department of Physics and Nuclear Engineering

2. Education

Doctor of Philosophy, Physics, Rensselaer Polytechnic Institute	2014
Master of Science, Physics, Rensselaer Polytechnic Institute	2011
Bachelor of Science, Physics, Rensselaer Polytechnic Institute	2009

3. Academic experience

Assistant Professor, Core Physics Deputy Program Director, USMA (FT)	2019 – Present
Assistant Professor, USMA (FT)	2018 – 2019
Core Physics Lab Course Director, USMA (FT)	2016 – 2017
Assistant Professor, USMA (FT)	2015 – 2016
Adjunct Lecturer, Rensselaer Polytechnic Institute (PT)	2015

4. Non-academic experience
None

5. Certifications or professional registrations
None

6. Current membership in professional organization
None

7. Honors and awards
None

8. Service activities
Institutional Service:
Society of Physics Students Officer in Charge 2018-Present

Professional Service:
None

9. Most important publications and presentations from the past five years
Hutchinson, David, Jay Mathews, Joseph T. Sullivan, Austin Akey, Michael J. Aziz, Tonio Buonassisi, Peter Persans, and Jeffrey M. Warrender. "Effect of Layer Thickness on Device Response of Silicon Heavily Supersaturated with Sulfur." *AIP Advances* 6.5 (2016): 055307.

Mailoa, Jonathan P., Austin J. Akey, Christie B. Simmons**, David Hutchinson**, Jay Mathews, Joseph T. Sullivan, Daniel Recht, Mark T. Winkler, James S. Williams, Jeffrey M. Warrender, Peter D. Persans, Michael J. Aziz, and Tonio Buonassisi. "Room-temperature Sub-band Gap Optoelectronic Response of Hyperdoped Silicon." *Nature Communications* 5.1 (2014): n. pag. Print.

10. Most recent professional development activities
New Instructor Training Mentor, National Training Center Leader Engagement Visitor

1. Name

Kathleen LeForte Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

M.S., Biotechnology, University of Pennsylvania, 2018
B.S., Life Science, United States Military Academy, 2009

3. Academic experience – institution, rank, title, dates, full or part time

USMA, Instructor, 2018-

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Military Assignments: (all fulltime)

Biology Instructor (2018- present); Battalion Communications Officer (S6)—Iraq (2015-2016); Signal Company Commander—Afghanistan and Fort Drum, NY (2014-2015); Network Operations Officer (DIV G6)—Fort Drum, NY and Afghanistan (2013-2014); Battalion Communications Officer (S6)—Afghanistan and Baumholder, Germany (2011-2013); Signal Platoon Leader—Baumholder, Germany (2010-2011)

5. Certifications or professional registrations

Signal Officer Basic Course qualification; Air Assault qualification; Signal Captain's Career Course (SCCC) qualification; Security plus certification.

6. Current membership in professional organization

N/A

7. Honors and awards

Academic: N/A

Military: Bronze Star Medal (2), Meritorious Service Medal (2), NATO Medal (2), Army Commendation Medal, Meritorious Unit Commendation (2), National Defense Service Medal, Afghanistan Campaign Medal (2), Iraq Campaign Medal (2), Global War on Terror Service Medal, Army Service Ribbon, Overseas Service Ribbon (3)

8. Service activities (within and outside of the institution)

Institutional Service: Department Personnel and Recruiting Officer; Department Web Editor; Course Director; Army Rabble Rouser Officer Representative; Cadet Leader Development Program Mentor

Professional Service: Member for Inter-disciplinary Chemistry, Engineering, and Biology Education Research Group at West Point; Judge for Duchess County Regional Science Fair (2019)

9. Publications and presentations from the past five years

Shuvaev V., Khoshnejad M., Pulsipher K., Kiseleva R., Arguiri E., Cheung-Lau J., **LeForte K.**, Christofidou-Solomidou M., Stan R., Dmochowski I., and Muzykantov V. (10 September

2018). "Spatially controlled assembly of affinity ligand and enzyme cargo enables targeting ferritin nanocarriers to caveolae." *Biomaterials*: 185, 348-359.

Kiseleva R., **LeForte K.**, et al. (2017, December). "Thrombomodulin delivery to vascular endothelium: modulation of targeting using various systems. Poster session presented at CT3N Symposium, Philadelphia, PA (ORAL).

10. Most recent professional development activities
Captain's Career Course (2013)

1. Name and Academic Rank

Eric Mowles Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

M.S., Military Operational Art and Science, Air University, 2016
M.S., Chemistry, Vanderbilt University, 2001
B.S., Chemistry, Virginia Military Institute, 1999

3. Academic experience – institution, rank, title, dates, full or part time

USAFA, Instructor, 2005-2008 (full time)
USAFA, Assistant Professor, 2008-2009 (full time)
USMA, Assistant Professor, 2018-present (full time)

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Military Assignments: (all full-time)

Commander, Detachment 5, Life Cycle Management Center, Gunter Annex, Maxwell AFB, AL, responsible for readiness, professional development and security for 1,900 personnel (2016-2018); Security Cooperation Officer, Military Assistance Program-Jordan, U.S. Embassy, Jordan (2014-2015); Scientist Assignments Officer, Air Force Personnel Center, Randolph, AFB, TX, executed worldwide assignments, AF mission needs and total force development for 1,100 officers (2013-2015); Chief, Aerospace Fuels Laboratory, 379 Expeditionary Logistics Readiness Squadron, Al Udeid, Qatar, led 5-member, $750K AFCENT area fuels laboratory, responsible for fuel stocks for over 32,000 sorties (2011-2012); Chief, Aerospace Fuels Laboratory, Air Force Petroleum Agency, RAF Mildenhall, United Kingdom, led $3.1M geographically separated unit testing $300M/year in cryogenics/fuels stock, laboratory hub for 18 bases (2010-2013); Education with Industry Student, Oak Ridge National Laboratory, TN, industry immersion program (2009-2010); Assistant Professor of Chemistry/Executive Officer, US Air Force Academy, CO, advised/assisted Dept Head on curriculum, personnel, budget, long-range plans of 40-member dept (2005-2009), Military Assistant to the Commander, Air Force Research Laboratory, Tyndall AFB, FL, logistics support for 210-member division (2003-2005).

5. Certifications or professional registrations

Air Command and Staff College, Squadron Officer School, Aerospace Basic Course, Level II Program Mgmt certification, Security Cooperation Mgmt Overseas Course, Level II SPRDE-Program Systems Engineer certification, Level II SPRDE-Systems Engineering certification, Level II SPRDE-Science and Technology Manager certification, Civilian Personnel Management course

6. Current membership in professional organization

N/A

7. Honors and awards

Academic: Honor Graduate, Virginia Military Institute; Squadron Officer School, top third graduate

Military: Meritorious Service Medal (5), Joint Services Commendation Medal, Air Force Commendation Medal, Air Force Achievement Medal, Meritorious Unit Award, AF Organizational Excellence Award, National Defense Service Medal, Global War on Terrorism Expeditionary Medal (2), Global War on Terrorism Service Medal, AF Overseas Ribbon Long, AF Expeditionary Service Ribbon with Gold Border (3), AF Longevity Service (4), Small Arms Expert Marksmanship Ribbon (Pistol), AF Training Ribbon,

8. Service activities (within and outside of the institution)
Institutional Service: Company Academic Counselor
Professional Service: N/A

9. Publications and presentations from the past five years
N/A

10. Most recent professional development activities
USMA Faculty Development Workshop; Air War College (enrolled)

1. Name

Chi K. Nguyen — Department of Chemistry and Life Science

2. Education – degree, discipline, institution, and year

Ph.D., Chemistry, University of California Santa Barbara, 2016
M.S., Chemistry, University of California Santa Barbara, 2005
M.S., Management, University of Maryland University College, 2003
B.S., Chemistry, Santa Clara University, 1997

3. Academic experience – institution, rank, title, dates, full or part time

USMA, Instructor, 2006-2008 (full-time)
USMA, Assistant Professor, 2008-2009; 2016-present (full-time)

4. Non-academic experience – company, entity, title, brief description of position, dates, full or part time

Military Assignments: (all full-time)

USMA, Department of Chemistry and Life Science, Assistant Chemistry Program Director responsible for program leadership (2018-present); 25th Infantry Division, 1st Stryker Brigade Combat Team, Brigade S2X and S2 responsible for intelligence collection, coordination, and dissemination to support staff and leadership planning and decision-making for a 4,000 person organization (2010-2013); 304th Military (MI) Battalion (BN), C Company (CO), Instructor/ Writer responsible for leader development and training of over 400 officers annually (2003-2004); 308th MI BN, Headquarters and Headquarters Company (HHC), CO Commander responsible for the welfare, training, and mission readiness of a 72 person organization (2001-2003); 308th MI BN, HHC, Battalion S-4 responsible for the logistics, maintenance, and support for subordinate units located at 27 locations across the United States (2001); 308th MI BN, A CO, Detachment Commander responsible for strategic level counterintelligence for Army installations and assets in a four-state area (2000-2001); 308th MI BN, A CO, Counterintelligence Officer responsible for mission and training support for a 75 person organization located in a 20 state area (1999-2000); 102nd MI BN (Republic of Korea), Headquarters and Headquarters Operational Company, Executive Officer responsible for the welfare, maintenance, training, and mission readiness for an 100 person organization (1998-1999); and Santa Clara University, Reserve Officer Training Corps, Gold Bar Recruiter responsible for scholarship information dissemination to students (1997-1998).

5. Certifications or professional registrations

Master Teacher Certification; Counterintelligence and Human Intelligence Management Course; Intermediate Level Education; Joint Planner; Space Enabler; Tactical Air Operations Officer; Basic Instructor Training Course;

6. Current membership in professional organization

American Chemical Society, Materials Research Society, Sigma Xi

7. Honors and awards

Academic: Sigma Xi, Outstanding Service Award

Military: Bronze Star Medal, Meritorious Service Medal (3), Army Commendation Medal (4), Army Achievement Medal (3), National Defense Service Medal, Afghanistan Campaign Medal (2), Global War on Terror Service Medal, Korea Defense Service Medal, Army Service Medal, Overseas Service Medal (3), North Atlantic Treaty Organization Medal

8. Service activities (within and outside of the institution)

Institutional Service: USMA Admission Committee Member; Faculty Manual Committee Member; Optimal Section Size Committee Member; Faculty Council Member; Academy Professor Search Committee Member; Title 10 Search Committee Member; Cadet Sponsorship Program; American Chemical Society West Point Student Section Officer-in-Charge; Department Academic Counselor; Chemistry Program Advanced Individual Academic Development Coordinator; Chemistry Program Technical Scholarship Advisor; West Point Marathon Team Officer Representative.

Professional Service: National Science Foundation Reviewer; Secretary for the Mid-Hudson Local Section of the American Chemical Society (ACS); ACS Committee on Professional Training; multi-year judge for the Westchester Science and Engineering Fair, Dutchess County Regional Science Fair, Tri-County Science Fair, and eCybermission; reviewer for ACS Applied Materials & Interfaces, Langmuir, and Journal of The Institution of Engineers (India): Series E; and reviewer and technical advisory board member for the in-house laboratory independent research program at U.S. Army Combat Capabilities Development Command Chemical Biological Center.

9. Publications and presentations from the past five years

(1) Alexander N. Mitropoulos, F. John Burpo*, **Chi K. Nguyen**, Enoch A. Nagelli, Madeline Y. Ryu, Jenny Wang, R. Kenneth Sims, Kamil Woronowicz, J. Kenneth Wickiser. “Noble metal composite porous silk fibroin aerogel fibers.” Materials, 12, 894 (2019).
(2) **Chi K. Nguyen**. "Destruction of Chemical Munitions on San Jose Island, Panama." Army Chemical Review. Winter 2018, 9-13. (Silver Quill Award)
(3) Damine Kudela, Stephanie. A. Smith, Anna May-Masnou, Gary B. Braun, Alesia Pallaoro, **Chi K. Nguyen**, Tracy T. Chuong, Sara Nownes, Riley Allen, Nicholas R. Parker, Hooman H. Rashidi, James M. Morrissey, Galen D. Stucky*. "Clotting Activity of Polyphosphate-Functionalized Silica Nanoparticles." Angew. Chemie Int. Ed. English, 54, 4018-4022 (2015).

10. Most recent professional development activities

Department Faculty Development Workshop Officer-in-Charge, 2019
Inter Academy Chemical Symposium Coordinator, 2019

1. Name

Logan James Phillips — Department of Physics and Nuclear Engineering

2. Education

Master of Science, Applied Physics, Yale University	2018
Bachelor of Science, Physics, The United States Military Academy	2009

3. Academic experience

Advanced Physics Course Director, USMA (FT)	2018 - present
Instructor of Physics, USMA (FT)	2018 - present

4. Non-academic experience

Commander, D Company, 35th Engineer Battalion, Ft. Leonard Wood, MO	2014 - 2016
Battalion Operations Officer, 169th Engineer Battalion, Ft. Leonard Wood, MO	2013 - 2016
Company Executive Officer, 102nd Sapper Company, Ft. Bragg, NC (deployed)	2012 - 2013
Battalion Construction Officer, 307th Engineer Battalion, Ft. Bragg, NC	2011 - 2012
Platoon Leader, 919th Engineer Support Company, Ft. Bragg, NY	2010 – 2011

5. Certifications or professional registrations

Command and General Staff College	2019
Engineer Captains Career Course	2013
Army Modern Combatives -1	2011
Explosive Ordinance Clearing Agent	2010
Airborne School	2007

6. Current membership in professional organization

Sigma Pi Sigma National Physics Honors Society; Association of the Unites States Army (Lifetime Member); Army Engineer Association (Lifetime Member)

7. Honors and awards

Bronze Order of the DeFluery Medal
Bronze Star Medal
Meritorious Service Medal
Army Commendation Medal
Army Achievement Medal (5th award)
Meritorious Unit Citation
National Defense Service Medal
Afghanistan Campaign Medal
Global War on Terrorism Service Medal
Military Outstanding Volunteer Service Medal
Afghan Service Ribbon
Overseas Service Ribbon
NATO Medal
Parachutist Badge
German Proficiency Badge (Gold)

8. Service activities

Institutional Service:

Faculty Council	2019-present
Teaching Excellence Committee	2018 - present
Leader Challenge Facilitator	2018 - present
Cadet Character Enhancement Program Facilitator	2018 - present
Officer Representative, USMA Powerlifting team	2019 - present
Academic Officer, USMA Boxing Team	2018 - present
Lead, Junior Faculty Research Seminar Series	2018 – present

9. Most important publications and presentations from the past five years

Kumpati S. Narendra, Logan Phillips, and Ashley Aponik. "Conventional, Mutual, and Iternmittent Adaptation" Center for Systems Science, Yale University, 2019.

Kumpati S. Narendra and Logan Phillips. "To Adapt or Not to Adapt: A New Paradigm" Center for Systems Science, Yale University, 2018.

Logan Phillips. "Joining the Long green Line: One Station Unit Training" Army Engineer Magazine, January 2016.

10. Most recent professional development activities

Command and General Staff Officer College (2019); Nuclear Weapons Effects, Policy, and Proliferation Certificate Program (2019); Junior Faculty Research Seminar Series (2018-2019); New Instructor Training (2018).

1. Name

Jason Ridgeway — Department of Geography and Environmental Engineering

2. Education

Doctor of Philosophy, Geography, Texas A&M University	2017
Master of Arts, Geography, University of Georgia	2006
Bachelor of Engineering, Civil Engineering, Texas A&M University	1996

3. Academic experience

Academy Professor, USMA (FT)	2018 - present
Assistant Professor, USMA (FT)	2017 - 2018
Assistant Professor, USMA (FT)	2008 - 2009
Instructor, USMA (FT)	2006 - 2008

4. Non-academic experience

Brigade Operations Officer, 191st Infantry Brigade	2012 - 2014
Battalion Operations and Executive Officer, 2nd Infantry Division	2010 - 2012
Company Commander, 173rd Airborne Brigade	2002 - 2004
Brigade Training Officer, 173rd Airborne Brigade	2001 - 2002
Battalion and Brigade Personnel Officer, 101st Airborne Division	1999 - 2000
Platoon Leader, 101st Airborne Division	1998 - 1999

5. Certifications or professional registrations

Engineer in Training, TX	1996

6. Current membership in professional organization

American Association of Geographers (AAG).

7. Honors and awards

Bronze Star (2)	
Meritorious Service Medal (4)	
Army Commendation Medal	
Army Achievement Medal	
National Defense Service Medal	
Afghanistan Service Medal with Campaign Star	
Global War on Terrorism Medal with Arrowhead Device	
Global War on Terrorism Service Medal	
Army Service Ribbon	
Overseas Service Ribbon (2)	
NATO Medal	
US Army 4-year ROTS Scholarship	1991
2002 Sul Ross Scholarship, Texas A&M University	1991

8. Service activities

Institutional Service:

Admissions Committee, USMA	2018 - present
Military Director, Center for the Study of Civil-Military Operations	2019 - present
Officer Representative, Cadet Club on Civil-Military Operations	2019 - present
Course Director for EV203, Physical Geography	2017 - present
Fourth Class Sponsor	2017 - 2018
Volunteer Organizer, Annual Symposium, Texas A&M University 2015	2015
Faculty Leader of Advanced Individual Academic Development in Vietnam	2008
Member, Martin Luther King Birthday Observance Committee	2007 - 2009
Faculty Leader of Advanced Individual Academic Development in Vietnam	2007
Faculty Advisor to U.S. Military Academy Geography Club	2007 - 2009
Geography Honors Thesis Advisor	2007 - 2008
Geography Program Website Administrator	2007 - 2009
Secretary, Faculty Search Committee	2007
Faculty Mentor	2006 - 2009
Geography Program Academic Advisor	2006 - 2009
Fourth Class Sponsor	2006 - 2008
Treasurer, Geography Association, University of Georgia	2004 - 2005

9. Most important publications and presentations from the past five years

Ridgeway, Jason. 2019. "Texas on the Edge of Empire: The View from the Galveston Consulate, 1850-1899." Paper presented at the Annual Meeting of the American Association of Geographers, Washington, D.C., 4 April.

Ridgeway, Jason. 2018. "The Practice of Public Topography: Teaching People to Appreciate Ordinary Places Using Books and New Media." Paper presented at the Annual Meeting of the American Association of Geographers, New Orleans, Louisiana, 14 April.

Ridgeway, Jason. 2016. "I Pity the Fish Downstream: Sense of Place and Interpretive Experience in Independence, Texas." Paper presented at the Symposium of the Association of Geography Graduate Students, College Station, Texas, 4 March.

Ridgeway, Jason. 2016. "Aggieland Grows Up: The Spatial Growth of Residential Areas in College Station, Texas, 1970-2010." Paper presented at the Annual Meeting of the American Association of Geographers, San Francisco, California, 31 March.

Ridgeway, Jason. 2008. "Let Them Have Dominion over All the Earth: Are Christians Anti-Environmental?" Middle States Geographer 41: 45-52.

10. Most recent professional development activities

Course Director for Physical Geography; Officer in Charge of New Instructor Training; Master Teacher Program; Evening lectures on metacognitive strategies for students; Annual meetings of the American Association of Geographers; Course Director Professional Development Seminars.

1. Name

Matthew Byrne Rogers — Department of Mathematical Sciences

2. Education

Doctor of Philosophy, Industrial Engineering, North Carolina State University	2016
Master of Science, Industrial Engineering, Arizona State University	2008
Master of Science, Engineering Management, University of Missouri Rolla	2002
Bachelor of Science, Engineering Management, United States Military Academy	1998

3. Academic experience

Program Director, Single Variable Calculus (Calculus I), USMA	2019
Assistant Professor, USMA	2008 - 2011, 2019

4. Non-academic experience

Battalion Commander, Fort Hood, TX	2017 - 2019
Division Engineer, Fort Hood, TX	2016 - 2017
Battalion Executive Officer, Schweinfurt, Germany	2012 - 2013
Battalion Operations Officer, Schweinfurt, Germany	2011 - 2012
Company Commander, Fort Bragg, NC	2005 - 2006
Assistant Brigade Engineer, Fort Bragg, NC	2004 - 2005
Deputy Division Planner, Fort Bragg, NC	2003 - 2004
Battalion Supply Officer, Bamberg, Germany	2001 - 2002
Battalion Maintenance Officer, Bamberg, Germany	2001
Company Executive Officer, Bamberg, Germany	2000 - 2001
Combat Engineer Platoon Leader, Bamberg, Germany	1999 - 2000

5. Certifications or professional registrations

Jump Master	2004
Ranger	2003
Airborne	2003
Air Assault	1997

6. Current membership in professional organization

Pi Mu Epsilon

7. Honors and awards

Bronze Star Medal	2004, 2006, 2012
Meritorious Service Medal	2006, 2011, 2013, 2019
Army Commendation Medal	2002
Army Achievement Medal	2000, 2001, 2002
Meritorious Unit Commendation	2012
Army Superior Unit Award	2011
National Defense Service Medal	1994, 2004
Afghanistan Campaign Medal	2006, 2010
Iraq Campaign Medal	2004
Global War on Terrorism Service Medal	2004

Army Service Ribbon	1998
Overseas Service Ribbon	2002, 2004, 2006, 2010
NATO Medal	2011
Combat Action Badge	2006

8. Service activities

Institutional Service:

Officer Representative, Football Team	2009 – 2011, 2019
Cadet Senior Thesis Co-Advisor	2011, 2019
Cadet Leader Development Training Lane Officer	2010
Cadet Honor Mentorship Program Facilitator	2008 - 2011

9. Most important publications and presentations from the past five years

Rogers, M. McConnell, B. Hodgson, T. Kay, M. King, R. Parlier, Thoney-Barletta, K. (2018). "A Military Logistics Network Planning System," *Military Operations Research. Vol* 23, December 2018, Pp. 5–24.

10. Most recent professional development activities

Faculty Development Workshop completion

1. Name
Charles A. Sulewski | Department of Mathematical Sciences

2. Education
Master of Science, Operations Research, Naval Postgraduate School 2005
Bachelor of Science, Mathematics, United States Military Academy 1996

3. Academic experience
MA256 Course Director, USMA (FT) 2019 - 2020
Assistant Professor, USMA (FT) 2017 - 2020
Instructor, Operations Research Systems Analysis Military Applications Course
Ft Lee (FT) 2011 - 2014
Assistant Professor, USMA (FT) 2010 - 2011
Assistant Professor, USMA (FT) 2008 - 2009
Instructor, USMA (FT) 2006 - 2008

4. Non-academic experience
Deputy Director, TRADOC Analysis Center, Ft Lee, VA 2014 - 2017
Deployed Operations Research Analyst, Iraq 2009 - 2010

5. Certifications or professional registrations
Engineer in Training, NY 2006

6. Current membership in professional organization
Pi Mu Epsilon – USMA Chapter Advisor 2008 - 2009
Pi Mu Epsilon – USMA Chapter Advisor 2018 – 2019

7. Honors and awards
Meritorious Service Medal, TRAC-LEE, Ft Lee 2017
Meritorious Service Medal, ORSA-MAC, Ft Lee 2014
Meritorious Service Medal, USMA 2011
Bronze Star, IRAQ 2010
Iraq Campaign Medal, IRAQ 2010
Meritorious Service Medal, USMA 2009
Meritorious Service Medal, Ft Sill 2003
Army Commendation Medal, Ft Bragg 2000
Army Achievement Medal, Ft Bragg 1999
Army Achievement Medal, Ft Bragg 1998
Army Achievement Medal, Ft Bragg 1997

8. Service activities
Institutional Service:
Assistant Program Director for Student Affairs, USMA 2017 - 2020

9. Most important publications and presentations from the past five years

Sulewski, C. *Stand Alone Facility Force Protection Study*, Training & Doctrine Command, Ft Eustis, VA, March 2017.

Sulewski, C. *Ground Mobility Study*, Presenter at Center for Faculty Development, West Point, NY, October 2015.

Sulewski, C. *Integrating the Analysis & Communicating the Results*, Training and Doctrine Command Analysis Center, Ft Lee, September 2015.

Sulewski, C. *Operational Energy Analysis, New Approaches to Analyzing Sustainment*, Presenter for the Department of Operational Sciences, Graduate School of Engineering and Management, Air Force Institute of Technology, December 2014

Sulewski, C. *Military History Detachment Command Study*, Presenter at the Army Operations Research Symposium, Aberdeen Proving Grounds, November 2014.

10. Most recent professional development activities

Assistant Program Director for Student Affairs within the Department of Mathematical Sciences at the United States Military Academy. Direct and support diverse faculty teams, comprised of junior and senior, military and civilian members, in the mission to educate, train, and inspire cadets to become leaders of character. Develop, execute, and supervise the Department Academic Counseling team while serving in an advisory capacity to integrate all Cadets Majoring/Minoring in Mathematics, Operations Research, Network Science, and Statistics into Department mission and events. Provide faculty development through observational feedback, communication, and mentorship. Serve on committees and in activities that further the goals of the Department, the United States Military Academy, and the Army.

1. Name
Andrew Steven Wilhelm Department of Physics and Nuclear Engineering

2. Education
Master of Science, Nuclear Engineering, University of Michigan 2018
Bachelor of Science, Physics, United States Military Academy 2008

3. Academic experience
Course Director, USMA (FT) 2019-Present
Instructor, USMA (FT) 2018-Present

4. Non-academic experience
Tank Platoon Leader 2009-2010
Tank Company Executive Officer 2010-2011
Airborne Reconnaissance Troop Commander 2014-2016

5. Certifications or professional registrations
None

6. Current membership in professional organization
IEEE, ANS

7. Honors and awards
BG William O. Darby Award: Distinguished Honor Graduate, Ranger School 2012
COL Ralph Puckett Award: Officer Honor Graduate, Ranger School 2012

8. Service activities
Institutional Service:
Faculty Council, USMA 2018-Present
Wrestling Team Officer Representative 2018-Present

Professional Service:
None

9. Most important publications and presentations from the past five years
Barker C, Bowen J, Wilhelm AS. Thayer 21: Teaching Physics the West Point Way. Invited talk at OpenStax CreatorFest (Houston, TX), April 2019.

Wilhelm AS, Jovanovic I. Gamma-Ray Spectroscopy via Measurement of Angular Distribution of Compton Scattering. Poster presented at: SORMA (Ann Arbor, MI), June 2018.

Liu K, Mapes J, Abraham S, Wilhelm AS, Latosz L, Chung E, Golduber R, Miller J, Trimas D, Kearfott K. Setup and Characterization of a Cesium-137 Dosimetry Calibration Source in a Space-Constrained Environment. Poster presented at: Consortium for Verification Technology Workshop (Ann Arbor, MI), November 2017.

Wilhelm AS, Jovanovic I. A Compton Spectroscopy Array for Extreme Pileup Measurements. Poster presented at: IEEE-NSS (Atlanta, GA), October 2017.

10. Most recent professional development activities

New Instructor Training	2018
Faculty Development Workshop	2019
Command and General Staff College	2019

Appendix C – Equipment

Labs and Associated Equipment in the Chemical Engineering Program

Common Core Courses	Page
CH101, General Chemistry I	C-2
CH102, General Chemistry II	C-2
CH151, Advanced General Chemistry I	C-3
EV203, Physical Geography	C-4
IT105, Introduction to Computing and Information Technology	C-4
PH205, Physics I (and PH255 Advanced Physics I)	C-5
PH206, Physics II (and PH256 Advanced Physics II)	C-6
Required Courses	
CH383, Organic Chemistry I	C-7
MC300, Fundamentals of Engineering Mechanics and Design	C-7
EE301, Fundamentals of Electrical Engineering	C-8
XE472, Dynamic Modeling and Control	C-9
MC311, Thermal-fluid Systems I	C-9
MC312, Thermal-fluid Systems II	C-9
CH485, Heat and Mass Transfer	C-10
CH459, Unit Operations Laboratory	C-11
Additional Facilities and Resources	
Other Chemical Engineering Experiments	C-12
Bartlett Hall (BH331 and BH341A) Computer Labs	C-13
Instrumentation Labs	C-14

Note: This Appendix provides a list of all experiments conducted by students in the program, as well as the major equipment associated with each experiment. Common core courses are included because these courses contain a significant amount of basic science content and in some cases a small amount of engineering topics, and they are taken by all students in the program. Some of the engineering electives also contain experiments, but only required courses are listed here. Descriptions of experiments in the elective courses can be found in the self studies for the programs offering the courses. We have also listed additional equipment available for back-up labs, demos, student research, and independent study.

CH101, General Chemistry I

- *Stoichiometry*: Equipment consists of electronic balance, Bunsen burner, test tube, and beaker. Students heat a compound to evolve oxygen, determine the mass of the products of the reaction, and determine percent error by comparing the theoretical mass of the products with the experimental mass.

- *Gas Laws*: Equipment consists of MicroLAB® environmental interface (temperature and pressure meter), mass balance, Bunsen burner, Erlenmeyer flask, graduated cylinder, test tube, and beaker. Students heat a compound to thermally decompose, determine the percent yield of oxygen, and then determine the mass percent of one component of the compound.

- *Thermodynamics*: Equipment consists of MicroLAB® environmental interface (temperature and time meter), thermally insulated cups, graduated cylinder, magnetic stir plate, and beaker. Students experimentally determine the change in enthalpy of a chemical reaction between an acid and base and compare that to the theoretical value.

- *Spectrophotometry*: Equipment consists of MicroLAB® interface (spectrophotometer), Bunsen burner, graduated cylinder, and cuvettes. Students observe the wavelength of light emitted from aqueous metal salt solutions in a flame test, and experimentally determine concentration of an unknown solution through the use of a spectrophotometer and the application of Beer's Law.

- *Intermolecular Forces:* Equipment consists of MicroLab® interface (thermistor), stir/hot plate, fume snorkel, beaker, test tube. Students explore the effects of intermolecular forces on the physical properties of substances, such as boiling point and solubility.

CH102, General Chemistry II

- *Orientation*: Equipment consists of air-displaced pipettes, pipette tips, weigh boats, and analytical balances. Students gain familiarity and practice with the use of air-displaced pipettes to reinforce concepts of accuracy and precision, and to develop statistical analysis skills based on results of pipetted amounts of water.

- *Titration*: Equipment consists of burette, burette stand and clamp, Erlenmeyer flask, magnetic stir plate, graduated cylinder, and beaker. Students experimentally determine the chemical components that contribute to hardness and alkalinity in water and what components are quantified with this technique. Students learn to do a complexometric titration to determine the hardness and alkalinity of water samples, develop foundational skills for analyzing water samples and assessing water quality, and refine note keeping skills for recording information in the laboratory notebook.

- *Spectroscopy*: Equipment consists of MicroLAB® environmental interface for spectrophotometry, cuvette, sample vials, volumetric flasks, and beakers. Students experimentally determine the chemical components that contribute to total dissolved iron levels in a water sample through visible absorption. Students prepare standard solutions, calculate their corresponding concentrations using the dilution equation, determine absorption of the standards using the MicroLab™ spectrophotometer to generate a calibration curve for subsequent use in determining the iron content in the water sample.

- *Water Analysis*: Equipment consists of MicroLAB® environmental interface for spectrophotometry and pH, cuvette, sample vials, volumetric flasks, beakers, burette, burette stand and clamp, Erlenmeyer flask, magnetic stir plate, graduated cylinder, and beaker. Using concepts and skills of previously conducted laboratory experiments, students design experiments that analyze water samples that they collect. Students experimentally determine the chemical components that contribute to total dissolved iron levels in a water sample through visible absorption, that contribute to water alkalinity, that contribute to water hardness. Students also have the option to determine pH of the water samples using a pH meter that they calibrate prior to use.

- *Buffers*: Equipment consists of MicroLAB® environmental interface for pH measurements, burette, magnetic stir plate, graduated cylinder, and Erlenmeyer flask. Students perform titrations of a strong acid with a strong base and a weak acid with a strong base. The buffering region of the titration curve is observed, and Ka values are determined.

- *Electrochemistry*: Equipment consists of MicroLAB® environmental interface consisting of a multimeter and electrochemical cell, beakers, graduated cylinder, electrical wire with alligator clips, copper, lead, magnesium, and zinc strips. Students construct a galvanic cell, determine reduction and oxidation conditions, study conditions that result in corrosion or prevent corrosion, and determine the standard electrochemical potential for the studied systems.

CH151, Advanced General Chemistry I

- *Measurements*: Equipment consists of an electronic balance, ruler, common glassware (beaker, Erlenmeyer flask, volumetric pipet, graduated cylinder, and buret), and unknown metal samples. Students design a protocol, use their protocol to determine the density of an unknown metal sample, and create a data table using correct uncertainty and significant figures. Students determine the appropriate glassware for measuring volume of dilute acid/base and evaluate associated cost, safety risks, and error analysis.

- *Stoichiometry*: Equipment consists of electronic balance, Fisher burner, glassware, unknown mixture (copper (II) sulfate and sodium chloride). Students determine the percent of copper in a solid mixture using separation techniques and stoichiometric calculations, calculate theoretical yield, percent yield, percent error, and determine the recovery of the metal is financially viable.

- *Intermolecular Forces*: Equipment consists of MicroLAB® environmental interface (temperature), various glassware and several different solutions of organic liquids, and salts. The purpose of this lab is to explore the effects of intermolecular forces on the physical properties of substances, such as boiling point and solubility. Key concepts introduced and explored include solubility and miscibility. Students must predict physical properties such as boiling point and miscibility based on their understanding of IMFs then experimentally test their hypothesis.

- *Gas Laws*: Equipment consists of MicroLAB® environmental interface (temperature and pressure meter), mass balance, Bunsen burner, glassware and syringe. Students experimentally determine the universal gas constant (R), experimentally determine the relationship between gas pressure and gas volume (Boyle's Law), and experimentally determine the relationship between gas temperature and gas pressure. Students report data in tabular and graphical format.

- *Thermodynamics (2-days)*: Equipment consists of MicroLAB® environmental interface (temperature and time meter), thermally insulated cups, glassware, bomb calorimeter, and commercial cereal samples. Students experimentally determine the change in enthalpy of a chemical reaction between an acid and base and compare that to the theoretical value and predict and experimentally determine enthalpy of reaction using Hess's Law and standard molar enthalpies of formation. Students determine the heat capacity of a bomb calorimeter, determine the heat of combustion for commercial cereal and use their data to determine the number of calories in the cereal, compare the experimentally determined calories to the manufacturer's value, and relate change in internal energy (ΔE) to change in enthalpy (ΔH).

- *Spectrophotometry*: Equipment consists of MicroLAB® UV/Vis spectrometer. Students use Planck's equation and the relationships among energy (E), frequency (f), and wavelength (λ) to calculate any of the three variables. Relate absorbance of a sample to concentration through a Beer-Lambert Law plot.

EV203, Physical Geography

- *Fluvial Processes*. Four stream tables are used to demonstrate fluvial processes. The stream tables have a large rectangular basin which holds artificial sand in three different sizes of particles (denoted by their color). The basin is angled slightly downward from the point of water discharge. The system includes a pump which circulates water to the top of the table after the water drains to the bottom of the reservoir. The instructor can shape the landscape by manually moving the sand into position. He/she can also control the rate of discharge, allowing for the demonstration of erosional processes, depositional processes, and the relationship between water velocity, stream competence, and stream capacity.

- *Groundwater Simulation Models*. Two groundwater simulation models demonstrate aquifers, aquicludes (or aquitards), artesian wells, permeability, and the like.

IT105, Introduction to Computing and Information Technology

- *<u>Programming, Sensors and Cybersecurity Lab Program</u>*: The lab program in this course provides an introduction to the principles behind the use, function, and operation of digital computers, information technology, and the cyber domain. The Python programming language is introduced with a primary focus on design analysis, algorithmic thinking, and problem solving. The programming concepts covered include sequence, selection, iteration, foundational data types and structures, functions, text processing, hierarchical decomposition using modular design, code tracing, code testing, and basic debugging. Cadets are given a high-level introduction to assembly language, data representation, operating and file systems, as well as sensors. Cadets spend a two-hour lab building a digital thermometer (including significant soldering) that utilizes an Arduino and later complete another two-hour lab that integrates servos to the sensor. Cadets load provided programs onto the Arduino and then are required to modify the code. Cybersecurity concepts are covered to include networking, threats, and some professional issues are addressed such intellectual property, copyright, and computing ethics. The course also includes a technical tour that consists of demonstrations of robotics, photonics, cybersecurity, and advanced CS/IT topics.

PH205, Physics I and PH255 Advanced Physics I

- *<u>Introduction to Measurements, Uncertainty, and Tools for Laboratory</u>*: Equipment consists of PASCO Science Workshop 750 interface. The purpose of this laboratory is to understand that all scientific measurements have uncertainty and to learn a way of properly reporting results. This laboratory provides the fundamentals in conducting analysis and properly communicating both data and results in laboratory worksheets/write-ups that will be used in all laboratories. The laboratory experiments are instructor led to enable students to practice the scientific analysis skills expected throughout the course.

- *<u>Linear Regression and Error Analysis – Kinematics</u>*: Equipment consists of PASCO Science Workshop 750 interface and projectile launcher kit. The purpose of this laboratory is to familiarize cadets to the laboratory technique of linearization and error analysis through kinematics. This laboratory exercise expands on the purpose and usefulness of linearization as a technique to test the model and determine an unknown quantity along with exercising the students' ability to conduct error analysis utilizing a number line.

- *<u>Friction</u>*: Equipment consists of PASCO Science Workshop 750 interface and the friction block kits. The purpose of this laboratory is to reinforce cadet understanding of the laboratory technique of linearization and error analysis through friction measurements. This laboratory introduces averaging measurements and the use of standard deviation of the mean as an absolute uncertainty.

- *Radiation Discovery Laboratory*: Equipment consists of a Geiger-Mueller tube connected to a PASCO Science Workshop 750 interface. The purpose of this laboratory is to reinforce cadet understanding of the laboratory technique of linearization and error analysis through radiation measurements.

- *Multi-concept Conservation Laws- COE & COLM*: Equipment consists of a PASCO car with catcher assembly, a steel ball, a digital scale, a projectile launcher and a PASCO motion sensor connected to a PASCO Science Workshop 750 interface. Cadets determine the kinetic and spring potential energy to calculate the spring constant of the launcher.

- *Multi-concept Conservation Laws- COE & COAM*: Equipment consists of a steel ball, projectile launcher, the PASCO arm-catcher assembly, and a PASCO motion sensor connected to a PASCO Science Workshop 750 interface. Cadets determine the rotational inertia of the arm-catcher assembly.

- *Expanding Physics Experimentation*: Cadets are randomly assigned one of the prior labs and required to deep dive into the physics of that lab and devise new experimental procedures to develop a deeper understanding of the physics. They are required to prepare a 10- to 15-minute brief on their findings for the next lab period.

PH206, Physics II and PH256 Advanced Physics II

- *DC Circuits and Resistance:* Equipment includes a breadboard, resistors, and multimeters. Lab groups are tested by building a circuit with a maximum and minimum total resistance using three provided resistors. Next, each lab group is provided a diagram of a circuit. The group must build a circuit matching the diagram and measure the total resistance of the circuit. Finally, cadets are introduced to improvised explosive devices (IEDs).

- *RC Circuits:* Equipment includes a PASCO interface, multimeters, capacitor, resistors, and assorted wiring. Given minimal directions, each lab group is tasked to calculate the time constant of their RC circuit. This is commonly done by using the PASCO interface to measure the voltage across the capacitor while charging or discharging.

- *RLC Circuits:* Equipment includes an inductor, variable capacitor, resistor, PASCO interface, and assorted wires. Given a capacitor, inductor, and resistor, each lab group must construct and measure the resonance frequency of an RLC circuit. The PASCO interface is used to produce the driving frequency.

- *Mechanical Waves:* Equipment includes a PASCO interface, string, and oscillator. This lab explores the fundamental relationship between wavelength and frequency for oscillating waves. Each lab group varies the tension on a string as a PASCO oscillator produces an oscillation at a known frequency. A theoretical equation must be linearized to solve for the linear mass density of the string after multiple trials.

- *Geometric Optics:* Equipment includes two converging lenses, an optical rail, an image producing light, and a view screen. Cadets must design a projector using refractive optics. Each lab group initially verifies the manufacturer's reported focal length of their provided converging lenses. Then, using the experimentally measured focal lengths, lab groups must design a two-lens system that produces a magnified-real image.

- *Refraction:* Equipment includes prism and PASCO collimated light. Cadets must experimentally determine the refractive index of a prism and demonstrate the critical angle and Brewster's angle.

- *Double Slit Experiment:* Equipment includes a laser, optics bench, and double slit filter. Cadets must measure the interference pattern observed and calculate the wavelength of the laser incident on the double slit filter.

- *Atomic Spectroscopy:* Equipment includes a PASCO spectrophotometer and a gas lamp with an unknown element. Cadets must conduct a measurement of the spectrum produced by the unknown element and match the element to a known spectrum.

CH383, Organic Chemistry I

- *Introduction to Organic Laboratory and Characterization Techniques*: Students recrystallize dimethyl terephthalate using a Craig tube and centrifuge. They learn how to use a Melt-Temp melting point apparatus and thin layer chromatography by characterizing mixtures of fluorene and fluorenone.
- *Organic Spectroscopy Techniques:* Students learn to operate the IR Spectrometer and gas chromatograph by analyzing some common organic compounds. They are also given instruction on how to operate NMR to obtain ^{1}H spectrum.
- *Acid/Base Extraction:* Students conduct liquid/liquid extraction using separatory funnel and benzoic acid, naphthalene, and 4-nitroaniline, conduct melting point and IR analysis on isolated products, and calculate % recovery.
- *Isolation of Trimyristin from Nutmeg:* Students use solid/liquid extraction utilizing reflux, recrystallization of product using Craig tube and centrifuge, melting point analysis, IR analysis, and calculate % recovery. The results are analyzed, discussed, and presented in a written report.
- *Synthesis of 2,5-dichloro-2,5-dimethylhexane by an S_N1 Reaction:* Students synthesize 2,5-dichloro-2,5-dimethylhexane form 2,5-dimethyl-2,5-hexanediol and then characterize the product using IR spectroscopy, thin layer chromatography, melting point, and ^{1}H NMR spectroscopy. The students calculate % yield, analyze, discuss, and present results in a written report.
- *Bromination of (E)-Stilbene:* Students synthesize stilbene dibromide from (E)-stilbene, and then analyze the product using IR spectroscopy, melting point, and ^{1}H NMR spectroscopy. The lab emphasizes development of an understanding of the goals of green chemistry. Students calculate % yield, present, analyze, and discuss results in a written report.

MC300, Fundamentals of Engineering Mechanics and Design

- *Simple Tension Laboratory*: Equipment consists of Uniaxial Tension Testing Machines, digital load meters, extensometers, and calipers. Students conduct axial tension tests on two different metallic specimens: steel and cast iron. During the laboratory, students record the axial loads required to produce specified deformations. This load and deformation data is subsequently utilized to calculate stress and strain for the material, which is then plotted as a stress-strain curve. Students then use the stress-strain curve for each material to determine several material properties, compare these experimental properties to accepted properties for the material, and compare the two materials in order to discuss practical uses for each.

EE301, Fundamentals of Electrical Engineering

- *Basic DC Circuit Analysis*: Equipment consists of two Agilent U1241A Digital Multimeters and a National Instruments ELVIS II$^+$ Virtual Instrumentation Suite. Students learn how to properly configure the power supply, build a resistive circuit, and connect measurement probes in the correct orientation to take voltage and current measurements. Students then calculate theoretical voltages and currents using the measured values of the resistors. Students then analyze their measured results by comparing them to theoretical values to verify Kirchoff's Voltage and Current Laws, Ohm's Law, and series and parallel resistance models.

- *Thevenin Equivalent Circuit and DC Maximum Power Transfer*: Equipment consists of two Agilent U1241A Digital Multimeters and a National Instruments ELVIS II$^+$ Virtual Instrumentation Suite. Students configure the power supply and virtual instrumentation (basic DMM) on the ELVIS, build two circuits that have the same output characteristics and measure output voltages and currents of the two circuits. They also take multiple measurements of the same circuit with a variable output resistor. Students then calculate theoretical voltages and currents and compare these theoretical values to their measured values to verify Thevenin Equivalent circuits and the DC Maximum Power Transfer equation.

- *AC Circuit Analysis and AC Node Voltage Analysis*: Equipment consists of two Agilent U1241A Digital Multimeters and a National Instruments ELVIS II$^+$ Virtual Instrumentation Suite. Students configure the power supply, virtual function generator and oscilloscope on the ELVIS. They build two separate circuits containing resistors, capacitors, and inductors and measure the voltages at different nodes in the circuits. Students then calculate theoretical voltages and currents and compare these theoretical values to their measured values to verify AC Node Voltage circuit analysis. They also learn about measurement error associated with an oscilloscope compared to a digital multimeter.

- *Op Amp Amplifiers and Active Filters*: Equipment consists of two Agilent U1241A Digital Multimeters and a National Instruments ELVIS II$^+$ Virtual Instrumentation

Suite. Students configure the power supply, virtual function generator and oscilloscope on the ELVIS. They design, build and test, a circuit using an Integrated Circuit (IC) Operational Amplifier and measure the linear and non-linear transfer functions. Students calculate theoretical values and compare them to measured values to verify Operational Amplifier characteristics and assumptions.

XE472, Dynamic Modeling and Control

- Four laboratories are conducted using the Rotary Servo Base Unit electromechanical system manufactured by Quanser. The system features a DC motor, gear-train, encoder, and a Simulink interface to implement controllers and visualize output data. Activities include modeling a first order system, open-loop and closed-loop control of a second order system, implementing a proportional-integral-derivative controller, and implementing full-state feedback control of a higher order system.

  Note: XE472 was replaced by CH367 in AY19. CH367 does not include a lab period.

MC311, Thermal-fluid Systems I

- *Open Channel Flow Laboratory:* Equipment consists of two A-8 Multi-Purpose Working Flumes that include flume, head tank with undershop gate (sluice), moveable tailgate, reservoir, circulating pump, flow meter, flow control valves, and orifice meters (high and low range) connected to on-board U-tube manometers for flow measurement. Students analyze actual forces on a sluice gate exposed to open channel flow using manometer taps in the gate. Students then calculate theoretical forces on the sluice gate exposed to an open channel flow using two methods: hydrostatic pressure distribution and conservation of linear momentum. Students compare results and comment on their findings.

MC312, Thermal-fluid Systems II

- *Internal Combustion Engine (Comparative Fuel Research) Laboratory*: Equipment consists of four one-cylinder, adjustable compression ratio, spark ignition, internal combustion engines and a gas analyzer. Students determine the effects of spark timing, compression ratio, rpm, and fuel octane on engine performance; analyze emissions with varying air-fuel ratio; and identify causes and demonstrate engine knock and how to avoid it.

- *Gas Turbine Laboratory*: Equipment consists of the Auxiliary Power Unit (APU) from an Army UH-60 Blackhawk helicopter instrumented with thermocouples and pressure transducers and driven with a dynamometer. Students measure temperature and pressures at various state points, torque, and RPM to determine performance characteristics of the turbine engine. Measured power is compared to that calculated using the First Law of Thermodynamics. Bleed air is examined using an exergy analysis. Uncertainty is quantified using statistical methods for a multi-sample experiment.

- *External Flow Measurement Laboratory*: Equipment consists of four wind tunnels with mounted flat plates, attached pitot rakes, and manometers. This laboratory demonstrates practical application of the Bernoulli Equation and demonstrates the effects of viscosity on fluid flow. Students measure variation in pressure using manometers, calculate velocities based on pressure differentials, and plot velocities as height from plate varies. Students discuss the resulting velocity profile in relation to the no-slip condition, viscous effects, and boundary layer.

- *Design of Experiment*: Design of Experiment: Cadets do one of four experiments: Drag of a parachute; hydraulic jump of an open channel; surface tension of an unknown fluid; and pipe friction in internal flow. Students design and conduct an experiment to calculate dimensionless groups for use in a model that can be used to estimate performance of a larger scale prototype using similarity. Emphasis is on use of dimensional analysis, uncertainty analysis and use of experimental procedures. Cadets used an open water trainer, the pipe friction trainer, a tank of unknown fluid, capillary tubes, mass scales, thermostats, and other items as requested by the cadets.

CH485, Heat and Mass Transfer

- *Temperature Profiles in Heat Exchangers*: Equipment consists of an Armfield HT30XC Heat Transfer Service Unit, an HT36 Extended Tubular Heat Exchanger, and a PC for data acquisition and logging. Students use the apparatus to measure the temperature profile along the axis of a double-pipe heat exchanger. By comparing this data with the theoretical model derived from a microscopic enthalpy balance, the students determine the overall heat transfer coefficient using regression techniques.
- *Measurement of Thermal Conductivity*: Equipment consists of an Armfield HT11C Linear Conduction Apparatus, an HT10XC Computer Control Unit, and a PC for data acquisition and logging. Students use the apparatus to measure heat conduction rates across various specimens, such as brass, aluminum and steel. Students are also asked to calculate the thermal conductivity of the specimen and to compare it with literature values.
- *Measurement of Thermal Conductivity in Cylindrical Plate*: Equipment consists of an Armfield HT12C Radial Conduction Apparatus, an HT10XC Computer Control Unit, and a PC for data acquisition and logging. Students use the apparatus to measure heat conduction rate in the radial direction across a cylindrical brass plate. Students are also asked to calculate the thermal conductivity of the specimen and to compare it with literature values.
- *Temperature Profile in a Heated Bar*: Equipment consists of an Armfield HT15C Extended Surface Heat Exchanger, an HT10XC Computer Control Unit, and a PC for data acquisition and logging. The HT15C is basically a cylindrical cooling fin with a heat source at one end, with the surface of the cylinder exposed to ambient air. Students use least squares regression to determine the local heat transfer coefficient by comparing the microscopic energy balance equation to measured data.

- *Heat Convection and Radiation*: Equipment consists of an Armfield HT14C Combined Convection and Radiation Apparatus, an HT10XC Control Unit, and a PC for data acquisition and logging. Students use the apparatus to measure rate of heat transfer from a heated cylinder, by mechanism of convection and radiation. By comparing results with an overall energy balance, the correct mechanism can be determined, and the incorrect mechanism can be ruled out.

CH459, Unit Operations Laboratory

- *Batch Chemical Reactor*: Equipment consists of an Armfield CEX Chemical Reactors Teaching Unit and a PC for data logging and control. Students use an Armfield batch reactor to measure the kinetics of the saponification of ethyl acetate with sodium hydroxide. Conductivity readings are used to calculate concentrations and overall conversion. Students develop a procedure to measure the rate constant for the kinetics expression at different temperatures, and to measure the effects of concentration on reaction rate. They are then expected to use the rate constant to model the reactor modeling using the CHEMCAD flow process simulator.
- *Hydrogen Fuel Cell*: Equipment consists of Ballard Power Systems Nexa® fuel cell stack and a PC for data monitoring and logging. Students determine the mass balance differential between hydrogen and air feeds and product water leaving. Students also compare measured power production to values calculated by enthalpy and free energy balances on the system. The students are required to develop a detailed model for the fuel cell stack using CHEMCAD. The system consists of a “dummy load” as well as a bank of lights that can be set to run 4-12 lights based on the required amperage. The students design the procedures for determining whether or not the mass and energy balances are satisfied.
- *Cooling Tower*: Equipment consists of a P.A. Hilton Benchtop Cooling Tower pilot plant. Students use the apparatus to measure energy and mass transfer across the tower packing, and to characterize flow patterns in the packing. Psychometric measurements are used to establish moisture content and specific enthalpy of all entering and leaving streams. The concept of number of transfer units (NTUs) is explored as a way to approach the idea of driving force. Students use CHEMCAD to perform a detailed tray-by-tray analysis of the column internals, and they compare calculated and measured results.
- *Carbon Dioxide Absorber*: Equipment consists of a Hampden Instruments H-6290-CDL Gas/Liquid Absorption Column. This system has been modified extensively over what was provided by the company, to include an automatic level control system on the liquid level in the column, automatic flow controllers on all feed streams, and electronic analyzer instrumentation on all inlets and outlets. The system also now includes a touch screen computer for interacting with the controllers. Students determine the amount of CO2 absorbed from a CO2/air stream into a water stream inside a packed column. The experiment introduces pilot plant operations, automatic control systems, and *in situ* measurements using CO2 sensors. Experimental data is compared to simulation data obtained on CHEMCAD, and the students are expected to develop their own process model on the simulator to explain the behavior of the system.

- *Continuous Chemical Reactor*: Equipment consists of an Armfield CEX Chemical Reactor Teaching Unit and a PC for data logging and control. Students measure and quantify the kinetics of the saponification reaction in a CSTR reactor. They measure the effects of flow rate and of baffles and mixing efficiency. They design an experiment to measure the activation energy for the reaction. Conductivity readings are used to calculate concentrations and overall conversion. Students are expected to use the measured parameters to model the reactor using the CSTR performance equation and the CHEMCAD flow process simulator.
- *Distillation*. Equipment consists of a Deltech packed distillation column and newly refurbished analyzers, control hardware, and control software. Students use this column to investigate the separation of methanol and n-propanol. Students take fluid samples and temperature readings at various positions within the column. Composition is measured using on-line refractometers that are standardized using a Gowmac gas chromatograph. Students then perform a tray-by-tray analysis using McCabe-Thiele methods. Txy and xy plots are generated with CHEMCAD, for McCabe-Thiele approach. Finally, students are required to perform a detailed simulation of the column using CHEMCAD.
- *Evaporator*: Equipment consists of Armfield UOP2 Double Effect Evaporator and Steam Generator. Students run the pilot plat to steady state and use mass and enthalpy balances to account for the differential between the steam consumed and the amount of product. In addition, the overall heat transfer coefficients calculated for the first effect, and heat exchanger. The experiment will also be also used to further reinforce process modeling and design on CHEMCAD by having the students develop a working process simulation for the unit. This unit has also undergone an extensive upgrade.

Other Chemical Engineering Experiments (used as back-up projects or as demos)

- *Membrane Separations*: Equipment consists of a Perfected Experiments, Inc., Membrane Air Separation Unit. Students use the pilot plant to measure oxygen and nitrogen transport across a Prism® membrane bundle. The students use this information to estimate the surface area of the membrane and to compare this to the specification provided by Air Products for the Prism® bundle.
- *Wetted Wall Absorber*. Equipment consists of an Armfield CES Wetted Wall Gas Absorption Column. Students determine the amount of oxygen absorbed from air into a falling film of oxygen-free water and use this information to determine the mass transfer coefficient. The experiment introduces pilot plant operation as well as in situ measurements using oxygen sensors. Experimental data is compared to simulation data obtained on ChemCAD, and the students are expected to develop their own process model on the simulator.
- *Liquid-Liquid Extractor*. Equipment consists of an Armfield UOP5 Liquid-Liquid Extraction rig that is used to separate propionic acid from a mixture of propionic acid and n-propyl bromide using water. This equipment includes automatic level controllers and pH analyzers, as well as a touch-screen computer to interact with the process controls. We have not used this instrument yet with students due to ongoing

safety concerns regarding the transfer of organic solvents and containment and ventilation of potential spills.

Bartlett Hall Computer Labs

Several courses use the Chemical Engineering Computer Laboratories, BH331 and BH431A. The courses include CH362 Mass and Energy Balances, CH363 Separation Processes, CH364 Chemical Reaction Engineering, CH367 Introduction to Automatic Process Control, CH485 Heat and Mass Transfer and CH402 Chemical Engineering Process Design. BH331 has 18 and BH431A has 9 Workstation Computers with the following specifications:

- System Type: Dell Optiplex 9020
- Operating System: Windows 10, 64 Bit
- Processor: Intel(R) Core(TM) i5-4570 CPU @ 3.20GHz
- Hard Drive: 500GB
- Network Adapter: 1 Gigabit
- DVD-CD ROM: HL-DT-ST DVD-ROM DTA0N
- RAM: Dual 4.0 Gigabit Modules (8GB Total) (utilizing 3GB right now)
- Audio Adapter: Integrated Digital High Definition
- Video Adapter: AMD Radeon HD 8490 / Intel Dual HD Onboard Graphic
- Monitors: Two Dell 19-inch screens, model P1913B
- Replacement Cycle: 4 years.

In Mass and Energy Balances, students are introduced to basic elements of the ChemCAD software, including flowcharting, mixers and splitters, stoichiometric and Gibbs reactors, and component separators. In Separation Processes, students use of ChemCAD to explore thermodynamic equations of state, calculate dew point-bubble point curves for graphical analysis, and design distillation, absorption, stripping, and liquid-liquid extraction equipment. In Chemical Reactor Design, students learn how to design and run kinetic reactors such as CSTRs and PFRs in ChemCAD. The software is also used heavily in Unit Operations Lab as well as in Process Design. Within the process design course, students use ChemCAD initial design flowcharting, solution of material and energy balances, equipment design, optimization and refining of designs, and estimating capital costs. All courses in the program also make heavy use of Mathematica and Excel, as well as other Microsoft Office products. The programming methods are developed with the students in the classroom setting. The Unit Operations Lab course (CH459), the Process Control course (CH367) and the Professional Practice course (CH400) also make significant use of chemical engineering process training simulators. Because of the interactions between the inside and outside operators, this software is best run in the computer lab environment.

Instrumentation Labs

While there are no courses in the program that are taken directly out of these labs, they are used by chemical engineering students and faculty for various research and independent study projects. The instruments in these facilities include:

- Bruker Avance III 400MHz FT-NMR
- Jasco V-630 UV-Vis spectrophotometer
- Agilent 8453 UV-Vis spectrophotometer
- CEM Mars microwave digester
- Rigaku NEXCG X-Ray Fluorescence
- Horiba JY Fluoromax Fluorimeter
- Thermo iCE 3000 AA/GF
- Thermo iCAP 6000 ICP
- Shimadzu QP2020 GC/MS
- Agilent 7890 GC
- Thermo Trace GC/ISQ MS
- TA Instruments Q200 DSC
- TA Instruments Q500 TGA
- TA Instruments Q400 TMA
- Dionex ICS 1500 IC
- Shimadzu LCMS2020 HPLC/MS/PDA
- Shimadzu Axima Confidence MALDI
- Shimadzu RF-6000 Fluorescence Spectrophotometer
- Micromeritics ASAP2020 Plus Porosimetry System
- Sartorius microbalance
- Bruker AFM
- Malvern Panalytical Empyrean XRD

1. **The Institution**

   a. *Name and address of the institution*

      United States Military Academy
      West Point, NY 10996

   b. *Name and title of the chief executive officer of the institution*

      Lieutenant General Darryl A. Williams, U.S. Army, Superintendent

   c. *Name and title of the person submitting the Self-Study Report*

      Matthew Armstrong, Associate Professor and Chemical Engineering Program Director

   d. *Name the organizations by which the institution is now accredited, and the dates of the initial and most recent accreditation evaluations.*

      The United States Military Academy was first accredited by the Middle States Commission on Higher Education in 1949. The most recent evaluation visit will be 29-31 March 2020, and re-accreditation is expected to follow. The institution was most recently formally re-accredited in 2010.

      The Chemistry Program in the Department of Chemistry and Life Science at the United States Military Academy was initially evaluated and certified by the American Chemical Society in 2013 and was most recently recertified in 2019.

2. **Type of Control**

   Federal

3. **Educational Unit**

All activities at USMA are under the direction of Lieutenant General Darryl A. Williams, Superintendent. His position is analogous to that of the president of a civilian college or university. Academic activities are directed by Brigadier General Cindy R. Jebb, Ph.D., Dean of the Academic Board. General Jebb's position is analogous to that of the vice-president for academic affairs and dean of the faculty at many civilian colleges. Brigadier General Curtis A. Buzzard, Ph.D. serves as the Commandant of Cadets and is responsible for the military and physical training activities at USMA.

The Superintendent, Dean, Commandant, the thirteen academic department heads, the Director of Admissions, the Director of Physical Education, the Director of Military Instruction, and the Director of Intercollegiate Athletics comprise the Academic Board. The Academic Board is statutorily responsible for developing and approving the curriculum at USMA.

At West Point, there are no separate deans for various disciplinary areas and no separate Dean for Engineering or head of the engineering educational unit. Under the Dean's direction are the Office of the Dean and thirteen academic departments, each headed by a Professor, United States Military Academy (PUSMA). Six of the thirteen academic departments are responsible for programs currently accredited by the Engineering or Computing Accreditation Commissions of ABET: the Departments of Chemistry and Life Science, Civil and Mechanical Engineering, Electrical Engineering and Computer Science, Geography and Environmental Engineering, Physics and Nuclear Engineering, and Systems Engineering.

There is no separate mission statement for the individual engineering programs but each academic department has its own mission statement that supports the goals of the Academic Program. The Academic Program incorporates a dynamic and integrated curriculum organized around interdisciplinary goals derived directly from Army needs and fulfilling the inherent responsibilities of institutions of higher education. USMA has a robust academic assessment program, managed by the Vice Dean for Academic Affairs within the Office of the Dean, to measure the effectiveness of goal attainment.

Figure D-1 presents a simplified organizational chart that shows the positions of the Academic Board members, the structure of the Office of the Dean, and the positions of the engineering and computing departments within the organizational structure of USMA.

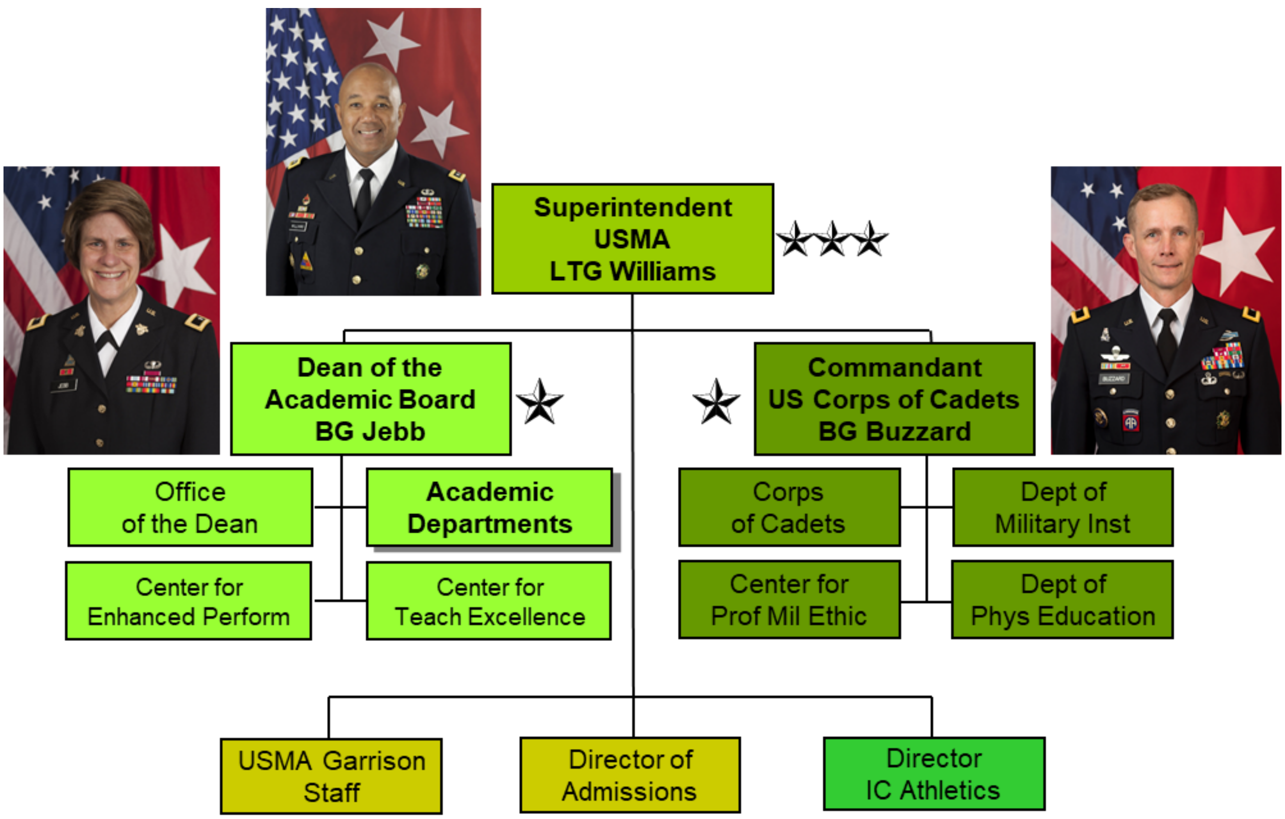


Figure D-1. Organizational Chart

4. Academic Support Units

The United States Military Academy's curriculum has two significant structural features. The first is a core of twenty-four courses that the Academy considers essential to the broad base of knowledge necessary for all graduates and a three-course core engineering sequence for those cadets who do not choose to major in engineering. This core curriculum, when combined with physical education and military science, constitutes the Military Academy's professional major. The second structural feature is the opportunity to specialize and explore an area in depth through the selection of an academic major consisting of not less than thirteen required or elective courses.

Figure D-2 presents an overview of the academic program. Courses in blue are Math, Science and Engineering (MSE) courses. Courses in red are Humanities and Social Science (HSS) courses. Courses in black are the Officership course and courses affiliated with each academic major. Courses in green are credit bearing courses from the Military and Physical Programs. Integrative Curricular Components are described within the figure.

Core (16 courses)
1. Chemistry 1
2. Physics 1
3. Chemistry 2, Physics 2 or Biology
4. Math (Modeling)
5. Math (Calculus)
6. Math (Statistics)
7. IT, Computing, and Cyber 1
8. Cyber 2, Science or Math
9. History 1 (U.S.)
10. Composition
11. Literature
12. Philosophy & Ethical Reasoning
13. Psychology
14. Economics
15. Political Science
16. International Relations

Engineering Sequence (3 courses)
25. Engineering Sequence course 1
26. Engineering Sequence course 2
27. Engineering Sequence course 3

Major (10 courses)
28. Major course 1
29. Major course 2
30. Major course 3
31. Major course 4
32. Major course 5
33. Major course 6
34. Major course 7
35. Major course 8
36. Major course 9
37. Major course 10 – Integrative Exp

Integrative Curricular Components
- Region-Culture Thread
- West Point Writing Program
- Gender, Sexuality, and Respect Thread
- MX400
- Three-Course Engineering Sequence

Core Culture/Region Thread (4 courses)
17. Physical Geography
18. Foreign Language 1
19. Foreign Language 2
20. History 2 (Region)

21. History 3 (Mil Art)
22. Leadership
23. Law
24. Officership (MX400)

Complementary Support (3 courses)
38. Complementary Support Course 1
39. Complementary Support Course 2
40. Complementary Support Course 3

Other Required Courses
3 x Military Science (total 4.5 CH) 1. Intro to Warfighting, 2. Fund of Small Unit Ops, 3. Platoon Ops
7 x Physical Education (total 5.5 CH) 1.Boxing, 2. Military Movement, 3. Pers Fit, 4. Survival Swimming, 5. Combat Apps, 6. Army Fit, 7. Lifetime Sport

Figure D-2. Overview of the Academic Program – Class of 2019 and beyond.

Table D-0 shows the names and titles of the individuals which have responsibility for the support units which teach courses required for the programs under review. These individuals are all department heads and hold a military rank of colonel (COL).

Table D-0 Individuals responsible for academic support units.

Department	Department Head	Title
Behavioral Science and Leadership	COL Everett Spain	Professor and Head
Chemistry and Life Science	COL John Burpo	Professor and Head
Civil and Mechanical Engineering	COL Fred Meyer	Professor and Head
Electrical Engineering and Computer Science	COL Jim Raftery	Professor and Head
English and Philosophy	COL Dave Harper	Professor and Head
Foreign Languages	COL Greg Ebner	Professor and Head
Geography and Environmental Engineering	COL Mark Read	Professor and Head
History	COL Gail Yoshitani	Professor and Head
Law	COL Dave Wallace	Professor and Head
Mathematical Sciences	COL Tina Hartley	Professor and Head
Military Instruction	COL Alan Boyer	Director
Physical Education	COL Nicholas Gist	Professor and Head
Physics and Nuclear Engineering	COL John Hartke	Professor and Head
Social Sciences	COL Suzanne Nielsen	Professor and Head
Systems Engineering	COL Rich Morales	Professor and Head

Not “Academic Departments” but support courses required for graduation

5. Non-academic Support Units

a. *Library*. The United States Military Academy Library, Mr. Christopher Barth, USMA Librarian and Associate Dean.

b. *Academic Computing*. Information and Educational Technology Division (IETD), COL Edward Teague, Chief Information Officer.

c. *Tutoring*. Tutoring falls under the Center for Enhanced Performance (CEP), Dr. Stephanie Marsh, Director CEP and is run by the Academic Excellence Program, Ms. Lori Houlihan, Director. Tutoring services include tutor training workshops, College Reading and Learning Association (CRLA) certification, Term End Exam preparation, and tutoring appointments. There are also a series of academic support courses run by the Academic Excellence Program, including:

- RS100 Student Success Course for Prepsters, Mr. Robert Ryan, Course Director
- RS101 Student Success Course, Mr. Robert Ryan, Course Director
- RS102 Reading Efficiency Course, Mr. Robert Ryan, Course Director
- RS103 Information Literacy and Critical Thinking, Ms. Laura Vetter, Course Director

d. *Teaching Assistance and Development.* Center for Faculty Excellence, Dr. Mark Evans, Director

e. *Placement.* Cadets may be excused from (validate) certain courses if they have sufficient knowledge of the subject to meet department standards. If a cadet shows unusual ability or has prior knowledge of a subject but does not validate the course, he or she may be enrolled in an advanced or accelerated course. Validation and placement criteria are developed by the departments offering the courses, with approval through the Academic Affairs and Registrar Services, Dr. James Dalton, USMA Registrar.

6. Credit Unit

From the 2020-2021 EAC Self-Study Questionnaire, "It is assumed that *one semester or quarter credit normally represents one class hour* or three laboratory hours per week. One academic year normally represents at least 28 weeks of classes, exclusive of final examinations. If other standards are used for this program, the differences should be indicated." This means that the ABET working assumption for a 3-credit course is

$$\frac{1\,\text{class hour / week}}{1\,\text{credit hour}} \times \frac{14\ \text{weeks}}{1\,\text{semester}} \times 3\,\text{credit hours} = 42\ \text{class hours per semester}$$

USMA follows a slightly different formula, but the result is consistent with the ABET working assumption. At USMA, credit hours are based on a calculation of planned time. On a semester basis, 40 hours of planned time are associated with 1.0 credit hour. This means that generally a 3.0-credit course requires 40 instructor contact (classroom) hours, with approximately two hours of preparation required for each hour in class. Exceptions are authorized with approval of the Curriculum Committee. The difference between the ABET working assumption and the USMA definition amounts to about 2 class hours per semester in a 3.0 credit-hour course.

The USMA definition of credit hours documented in Part I of the Academy's Redbook (Course Catalog). The Redbook can be found by the general public on Academy's external web page at https://www.westpoint.edu/academics/curriculum. The calculation of credit hours appears on pages 21-22 of the 2020 Redbook.

7. Tables

Tables D-1 and D-2 appear on the following two pages.

Table D-1. Chemical Engineering Program Enrollment and Degree Data

	Academic Year		Enrollment Year					Total Undergrad	Total Grad[3]	Degrees Awarded			
			1st	2nd	3rd	4th	5th			Associates[3]	Bachelors	Masters[3]	Doctorates[3]
Current Year		FT[1]	0	36	26	29	1	92					
		PT[2]											
1 (AY19)		FT[1]	0	26	30	25	2	83			21		
		PT[2]											
2 (AY18)		FT[1]	0	32	25	19	0	76			17		
		PT[2]											
3 (AY17)		FT[1]	0	29	21	16	1	66			23		
		PT[2]											
4 (AY16)		FT[1]	0	17	16	23	0	57			21		
		PT[2]											

Enrollment figures (head count) for the current and preceding four academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the on-site visit.

Notes:

1. FT--full time
2. PT--part time--there are no part-time students in our program.
3. There are no graduate students and no associate, masters, or doctorate degrees awarded by our program.

Table D-2. Personnel – Chemical Engineering Personnel, Fall 2019

	HEAD COUNT		FTE[2]
	FT	PT	
Administrative	3.0[1] (0.3[2])	0.0	3.0[1] (0.3[2])
Faculty (tenure-track)	10.0[3]	0.0	10.0[3]
Other Faculty (excluding student assistants)	0.0	0.0	0.0
Student Teaching Assistants	0.0	0.0	0.0
Technicians/Specialists	8.0[1] (1.0)[2]	0.0	8.0[1] (1.2)[2]
Office/Clerical Employees	3.0[1] (0.3)[2]	0.0	3.0[1] (0.3)[2]
Others	0.0	0.0	0.0

Notes:

1. Total for the Department of Chemistry and Life Science.
2. The number in parentheses is very approximately what the department allocates to the chemical engineering program.
3. Number of faculty from the Department of Chemistry and Life Science who taught required chemical engineering courses in AY2020. An additional 34 faculty from other departments also teach chemical engineering students in required courses offered outside the department.