UNITED STATES MILITARY ACADEMY
WEST POINT

Chemical Engineering

Advisory Board Meeting

13-14 April 2023

United States Military Academy
Department of Chemistry and Life Science

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Meeting Schedule

Date	Time	Event	Location	OIC	Task
13APR	NLT1700	Pick up 15 PAX van	Motorpool	MAJ Yi/ MAJ Bowers	
	1730-1745	Pick up Board Members From Hotel	Holiday Inn Express	MAJ Yi/ MAJ Bowers	Transport of Board Members to Bear Mountain Inn
	1800 - UTC	Dinner	Bear Mountain Inn Fort Montgomery, NY	Dr. Nagelli	Reservation (MAJ Mandes)
14APR	0730	Pick up Board Members From Hotel	Holiday Inn Express 1106 Route 9W Fort Montgomery, NY (845) 446 - 4277	MAJ Yi/MAJ Bowers	Pick Up Board (Yi/Bowers) Escort to BH465 (Dr. Nagelli)
	0745 - 0800	Arrival and Coffee/Light Breakfast Items	Bartlett Hall 465 (table side)	Dr. Nagelli, LTC Cowart	Light Breakfast Items (Dr. Yuk)
	0800 - 0830	**Session 1:** Introductory remarks and ABET orientation	BH465	COL Burpo & COL James, Dr. Nagelli/LTC Cowart	
	0830 - 0920	**Session 2:** Assessment & Program Objectives Feedback from Board, Future Challenges I	BH465	Prof. Biaglow	
	0920 - 0935	**Board Surveys**	BH465	Dr. Nagelli/LTC Cowart	Survey Parts 1 & 2
	0935 - 0950	**Session 3:** Bioengineering Electives	BH465 (table side)	Dr. Yuk	
	1000 - 1050	**Career Panel (Cows)**	BH465 (chair side)	LTC Cowart	
	1050 - 1130	**Cadet Discussions (Fisties and Cows)**	BH465 (chair side)		
	1135 - 1300	**Lunch**/Firstie Mock Interview Round Robin	BH465	Dr. Nagelli	Available Faculty Pick Up Lunch from IKE Hall to BH Loading Dock
	1300 - 1330	Board feedback on cadet interactions	BH465	Dr. Nagelli/LTC Cowart	
	1340 - 1430	**Session 4:** Program Updates/Board Survey II	BH465	LTC Cowart	
	1430 - 1500	**Session 5**: Future Challenges II	SBBH	Dr. Nagelli/LTC Cowart/ LTC Belanger	
	1500 - 1600	Wrap up/Lab Tour/Return to Hotel	BH465	MAJ Yi/Dr. Nagelli	

Dr. Enoch Nagelli. Cell: (630) 452 3653

Meeting Goals

1. Advisory Board Members Roles
   - Assessment Data
   - Objectives Assessment
   - Curricular Challenges
   - Complete Surveys

2. Board Members have discussions with chemical engineering faculty and cadets

3. Tours of chemical engineering lab, research, classroom space complete

4. Complete travel paperwork after the meeting concludes or save all paperwork for processing after returning

Chemical Engineering

Advisory Board Meeting

13-14 April 2023

1. Introductory Remarks

United States Military Academy
Department of Chemistry and Life Science

ABET | Engineering Technology Accreditation Commission

Accredited **1 October 2012** to present

Next Record Year: **AY2025-2026**

ABET Visit: **Early September 2026**

Why ABET Accreditation?

- Confidence that program has met standards essential to prepare graduates to enter STEM fields
- Keeps us in touch with the engineering profession
- Helps USMA (and ChemE) recruiting (2020 – 29; 2021 - 20; *2022* - 23; *2023 -13; 2024 ~21; 2025~34; 2026~30*)
- Provides important opportunities for graduates
- Allows USMA engineering majors to take the Fundamentals of Engineering (FE) Exam
- It is required by Army Regulations (10-87).

Thoughts to Consider

- The ABET process is impacts faculty time
  - USMA is a small undergraduate college (<5,000 students) with limited faculty and high faculty turnover
- The ABET accreditation is important to the institution and to the Army (so we tend to do it well)
- The only way we can be successful with ABET is to orient our program processes around the ABET criteria
  - By doubling up our efforts we obtain some efficiency
  - Much of what follows is oriented around the ABET processes and terminology
  - We need to be strategic in deciding on new initiatives

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Terms You Should Know

- **Program Educational Objectives (PEOs)**
  - Gleaned by asking *program constituents*
    - For us: Army, profession, graduate schools, other
  - **Our external *Advisory Board* a key resource.**
  - Desired professional accomplishments of graduates **5-7 years after graduation**
  - Adjust every 3 years or so…

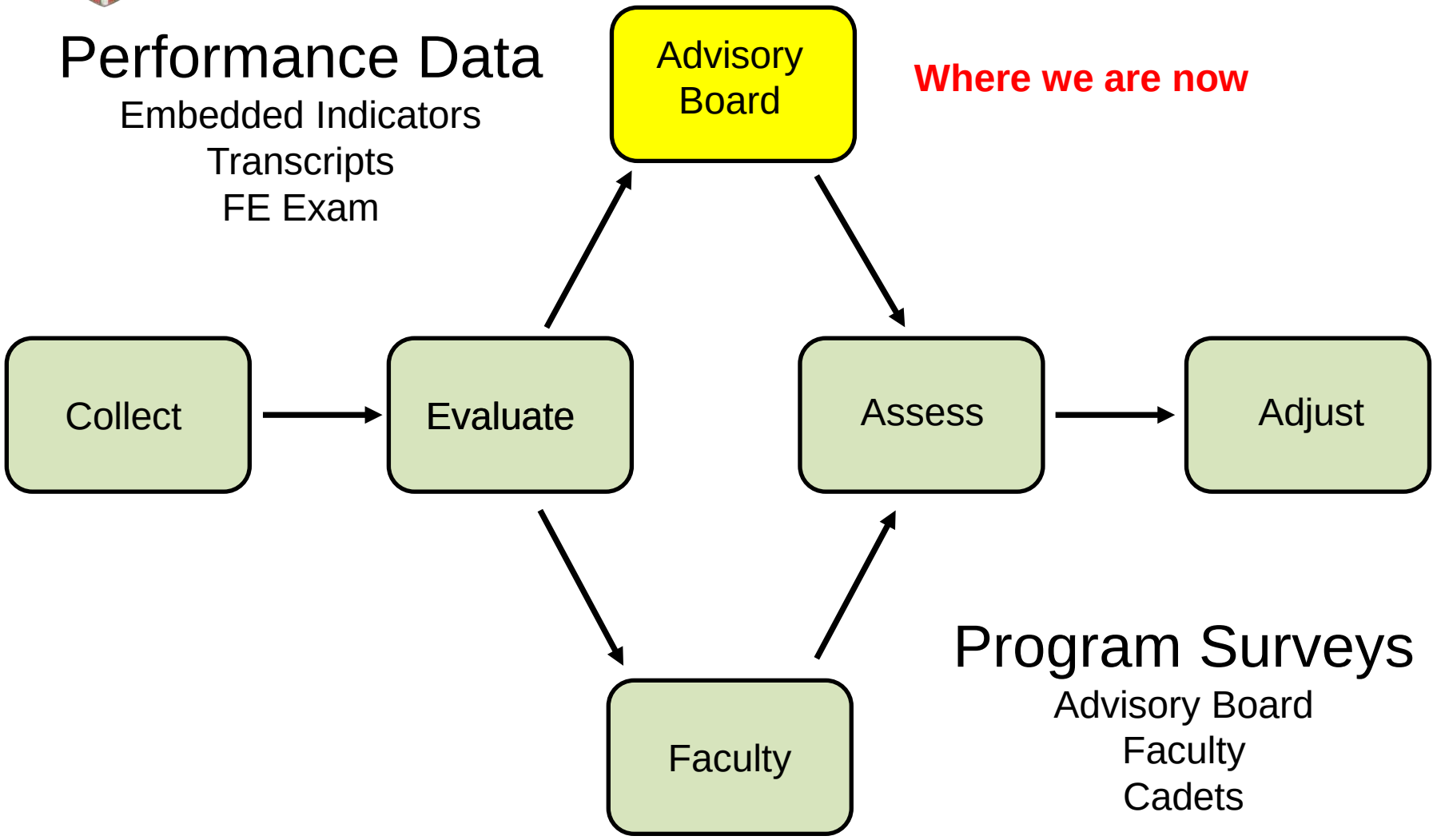
- **Student Outcomes**
  - What students should be able to do **at graduation**
  - Must be **measurable**
  - Designed to lead naturally to the PEOs
  - Assess/evaluate some fraction yearly.

- **Assessment → Continuous improvement**
  - Collect meaningful data to evaluate performance indicators (PIs)
  - Assess PIs for outcome attainment → information → COAs for change
  - Implement change
  - Assess its effects and level of success (“closing the loop”)
  - Repeat all the above
  - Periodically check and adjust both Student Outcomes and PEOs

Assessment Process

Performance Data

Embedded Indicators
Transcripts
FE Exam



Where we are now

Program Surveys

Advisory Board
Faculty
Cadets

Chemical Engineering

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13-14 April 2023

2. Program Assessment

United States Military Academy
Department of Chemistry and Life Science

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Student Outcomes (AY19 & beyond)

Identical to ABET 1-7 plus one additional outcome (8)

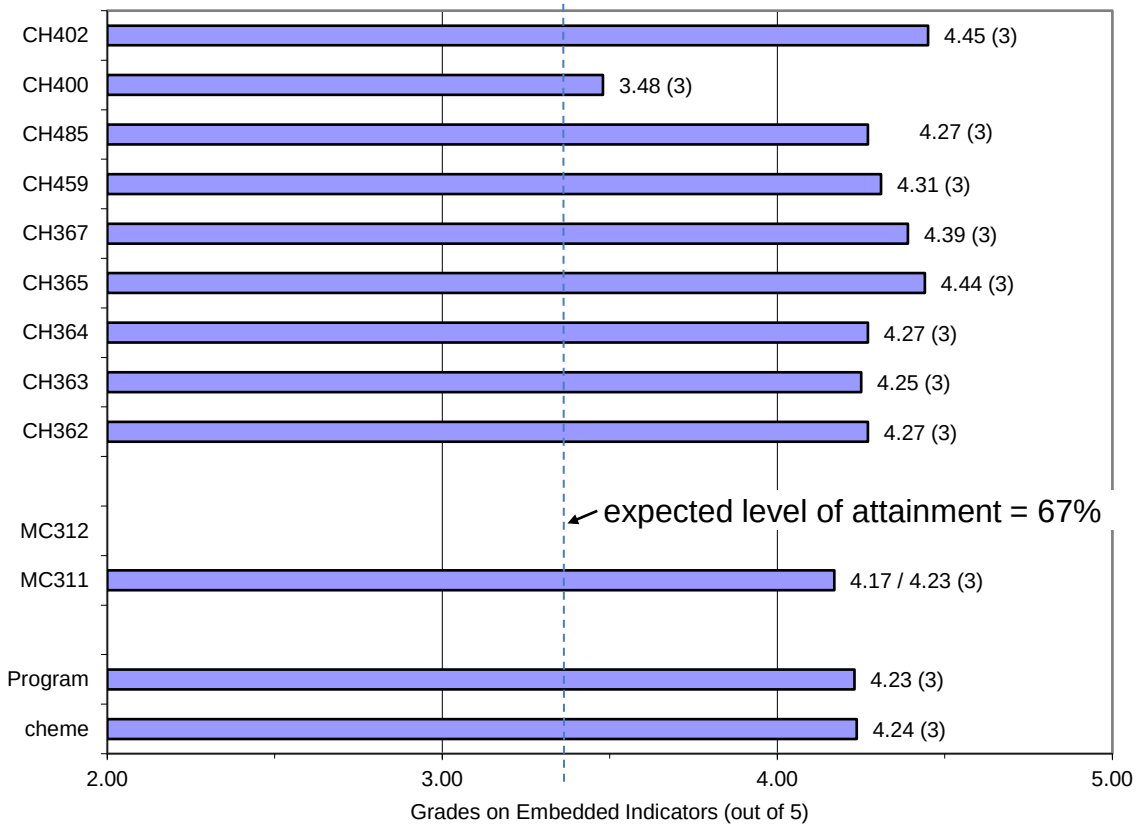
On completion of the chemical engineering program, our graduates will be able to:

1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
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. Communicate effectively with a range of audiences.
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. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.
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.

Example Data: Coursework Embedded Indicators

Student Outcome 1

Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.



MC311 and MC312 have two scores. The first is for chemical engineering and the second is course-wide.

Values in parentheses are coverage ratings from Table 5-4

Rubric:.

3: Unique embedded indicator with clear rubric or cut scale.

2: Outcome was graded but grades are convoluted, or part of the outcome is not covered.

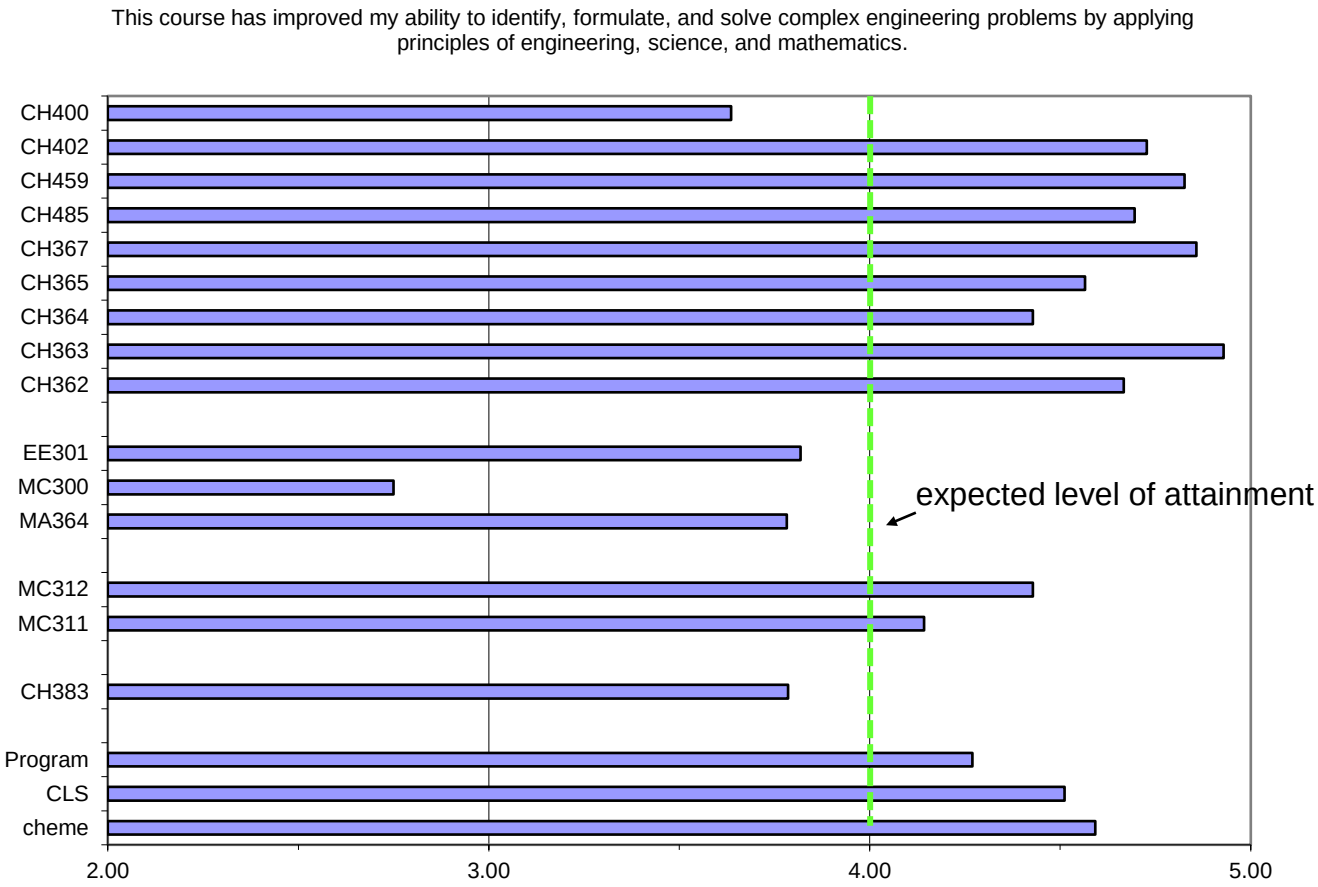
1: Correlation to outcome but no assessment

0: No coverage or correlation

Data shown here is for Class of 2022
Similar data is collected for all 7 ABET student outcomes
Summary of all data is shown on next slide

Example Data: End-of-Semester Surveys

Student Outcome 1



Program – average of all 15 courses above
CLS – chemistry and life science courses
cheme – chemical engineering courses in CLS

Data shown here is for Class of 2022
Similar data is collected for all 8 ABET student outcomes
Summary of all data is shown on next slide

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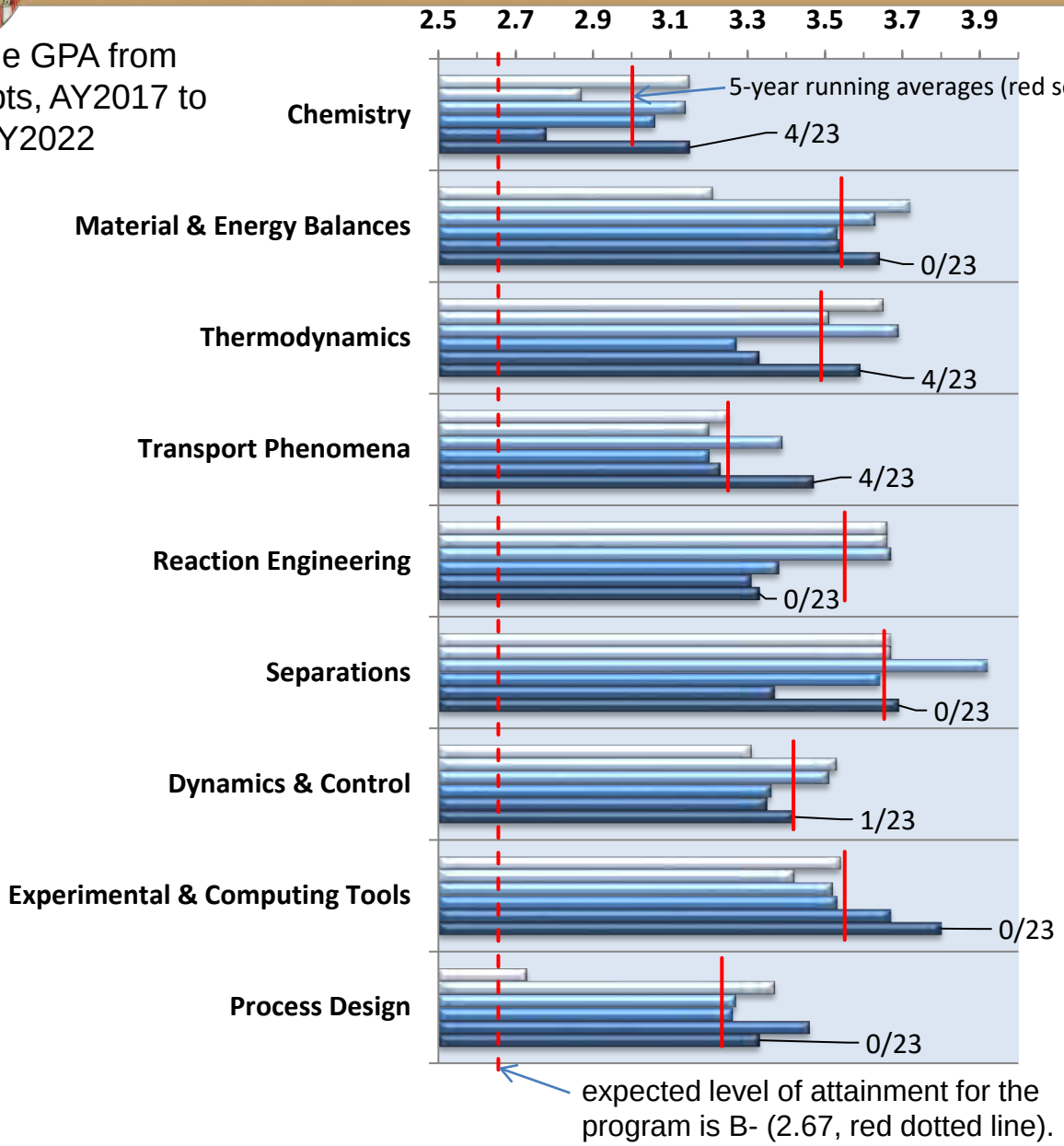
Topical Outcomes Evaluation

Student Outcome 8: Understanding of the Chemical Engineering Curriculum

Average GPA from Transcripts, AY2017 to AY2022



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

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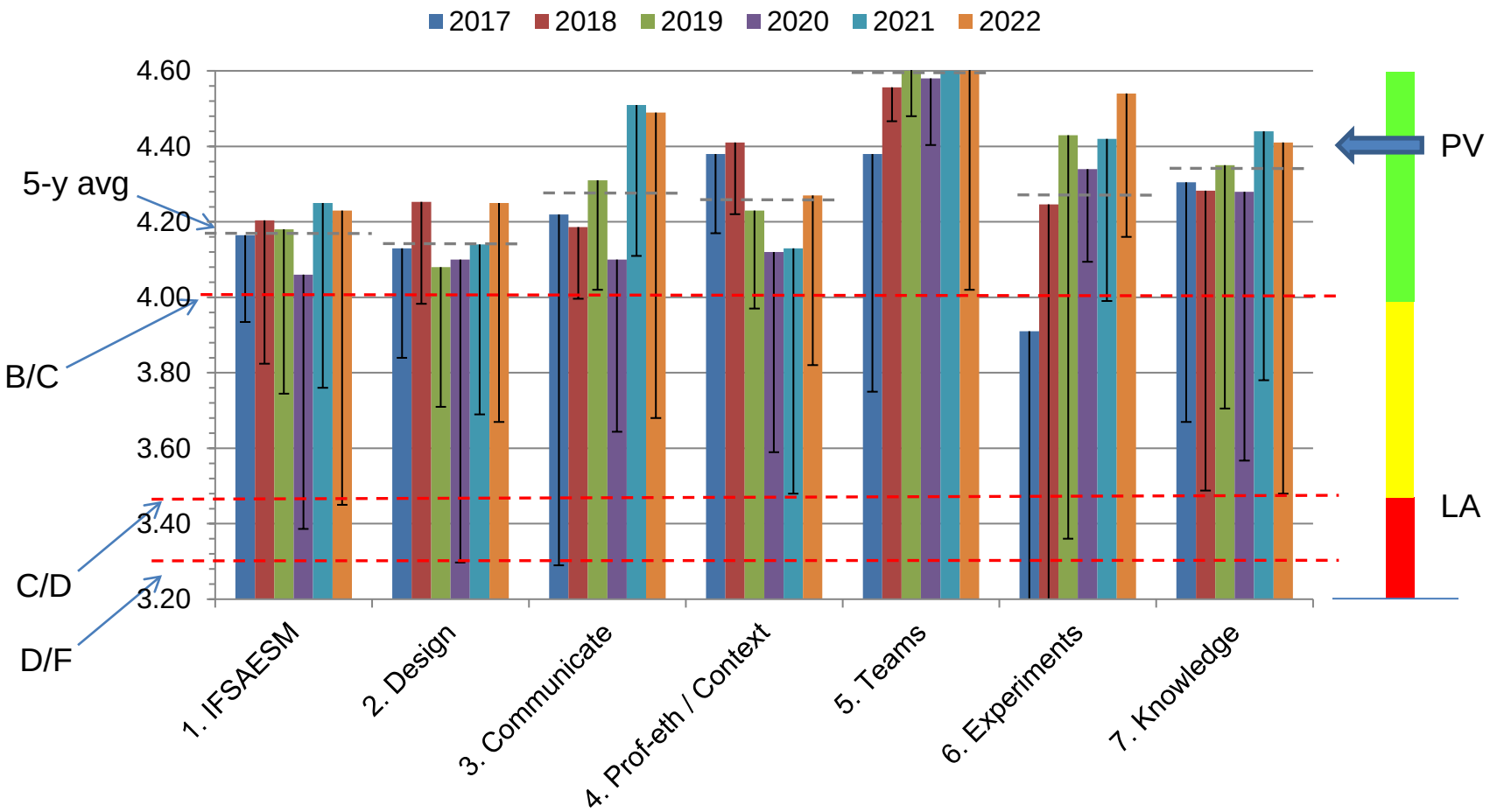
Performance on Embedded Indicator
Program Averages AY2017-22

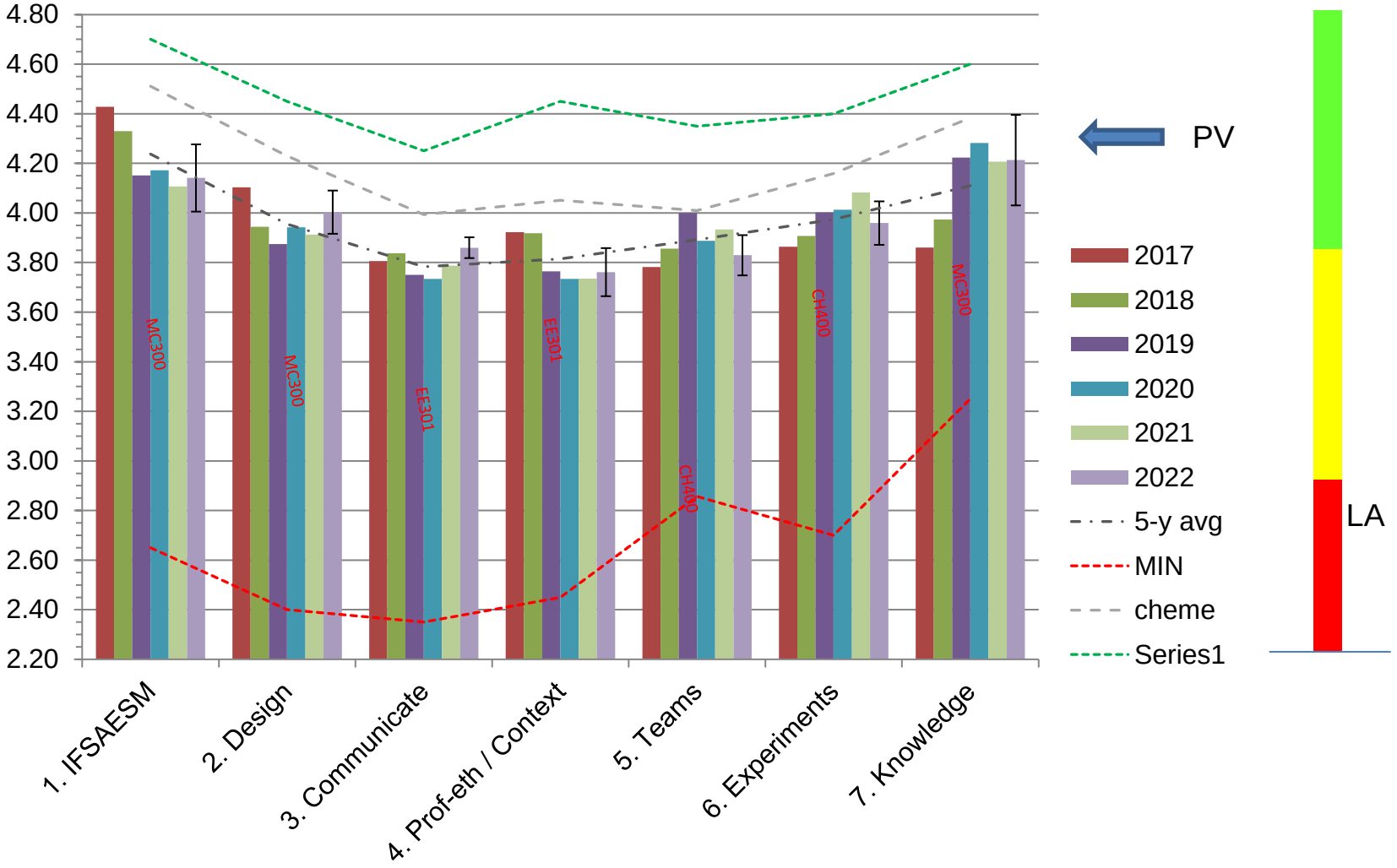


Error bars are minimum scores from course assessments.

Expected levels of attainment are the 5-year averages

End-of-Semester Surveys Program Aves. From AY17-AY22

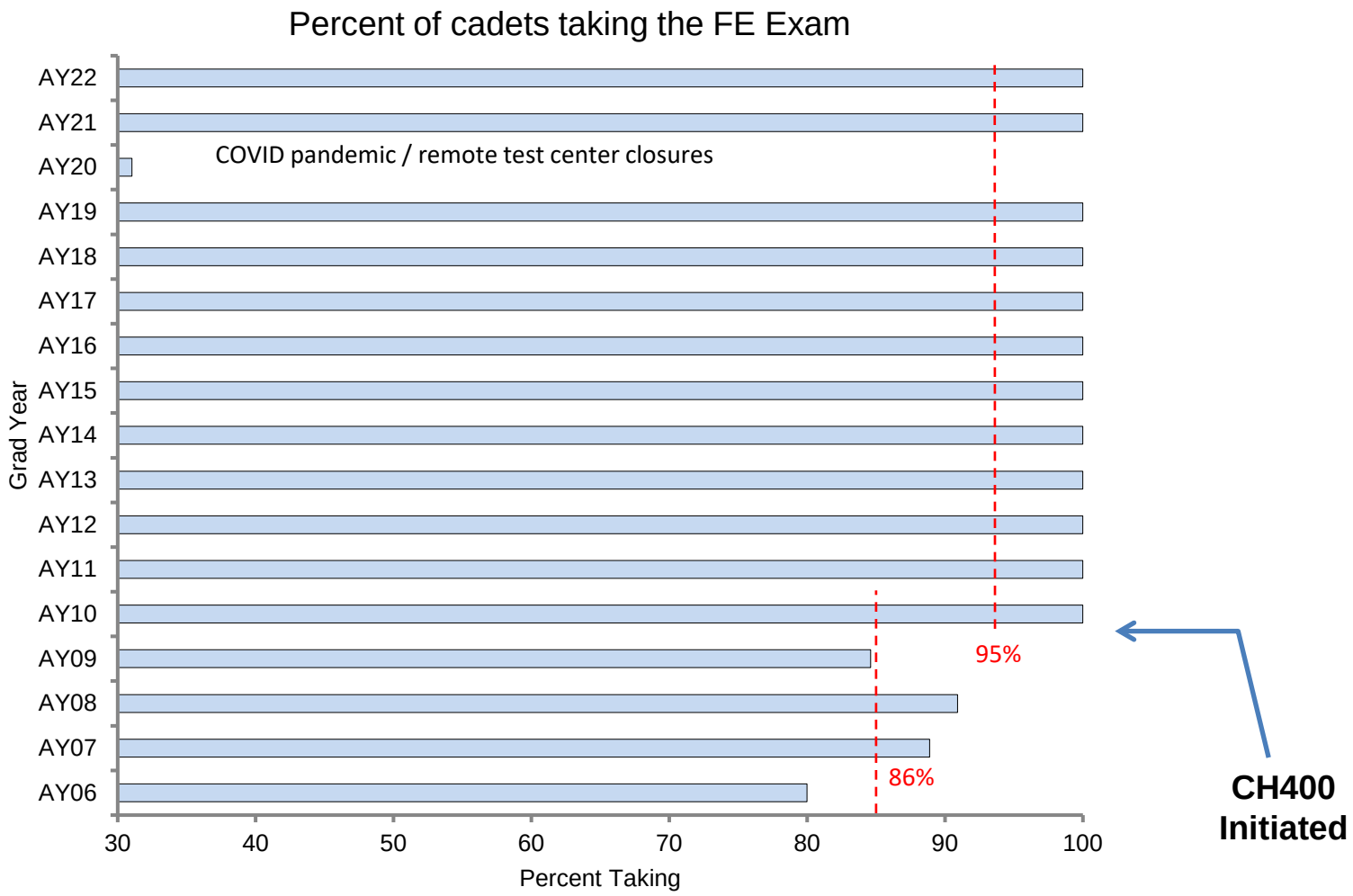
Error bars are standard deviations.
Expected level of attainment is the 5-y average



Fundamentals Engineering Exam Results

Fundamentals of Engineering Exam

Student Outcome 7: Acquire and apply new knowledge as needed, using appropriate learning strategies



Fundamentals of Engineering Exam

Student Outcome 7: Acquire and apply new knowledge as needed, using appropriate learning strategies

National, (+/- ~1%):

2022	70.7%
2021	74.0%
2020	74.6%
2019	77.0%
2018	75.0%
2017	74.0%
2016	79.0%
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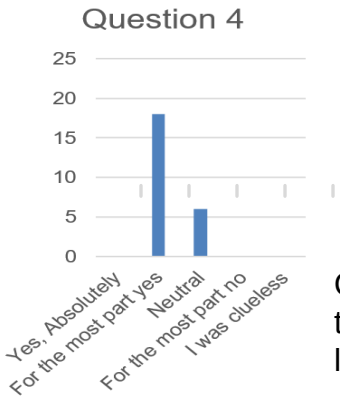
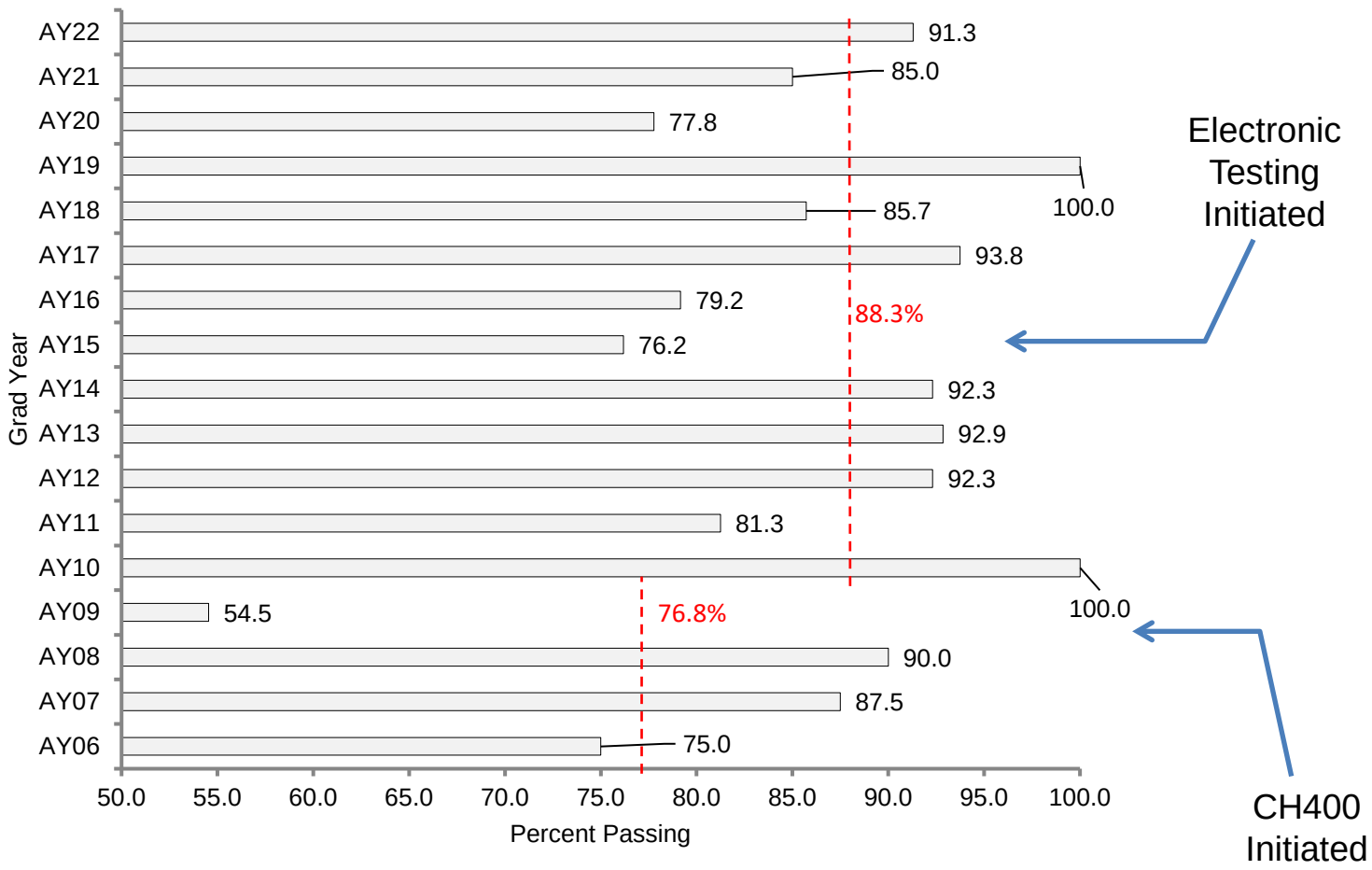
2015	77.4%
2014	89.0%
2013	86.3%
2012	85.1%
2011	87.0%
2010	87.0%
2009	84.0%
2008	87.0%
2007	87.0%
2006	87.0%

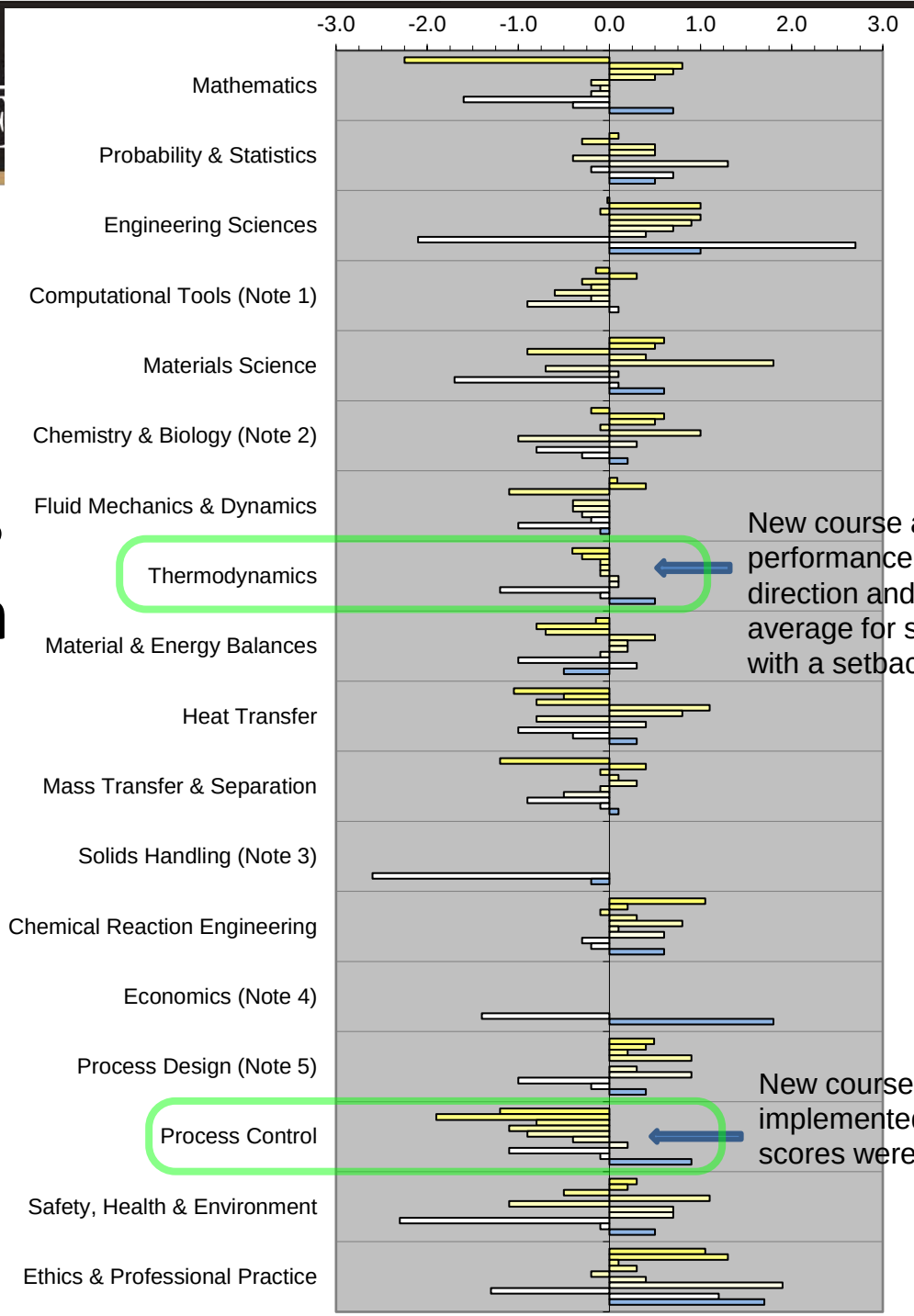




Question 4, Post FEE Survey: For the questions on the exam that seemed new to you, were you able to learn the material on the spot?

Topical Outcomes Evaluation

Deviations from National Averages AY13 to AY22



New course added in AY13. Trend in performance continues in the right direction and has been near the national average for several successive years, with a setback in AY20 due to COVID-19

Notes:

(1) This topic dropped in 2021.
(2) "& Biology" added in 2021
(3) Economics. separated from process design in 2021.
(4) New exam spec in 2021
(5) Was Proc Design & Econ 2020 and before

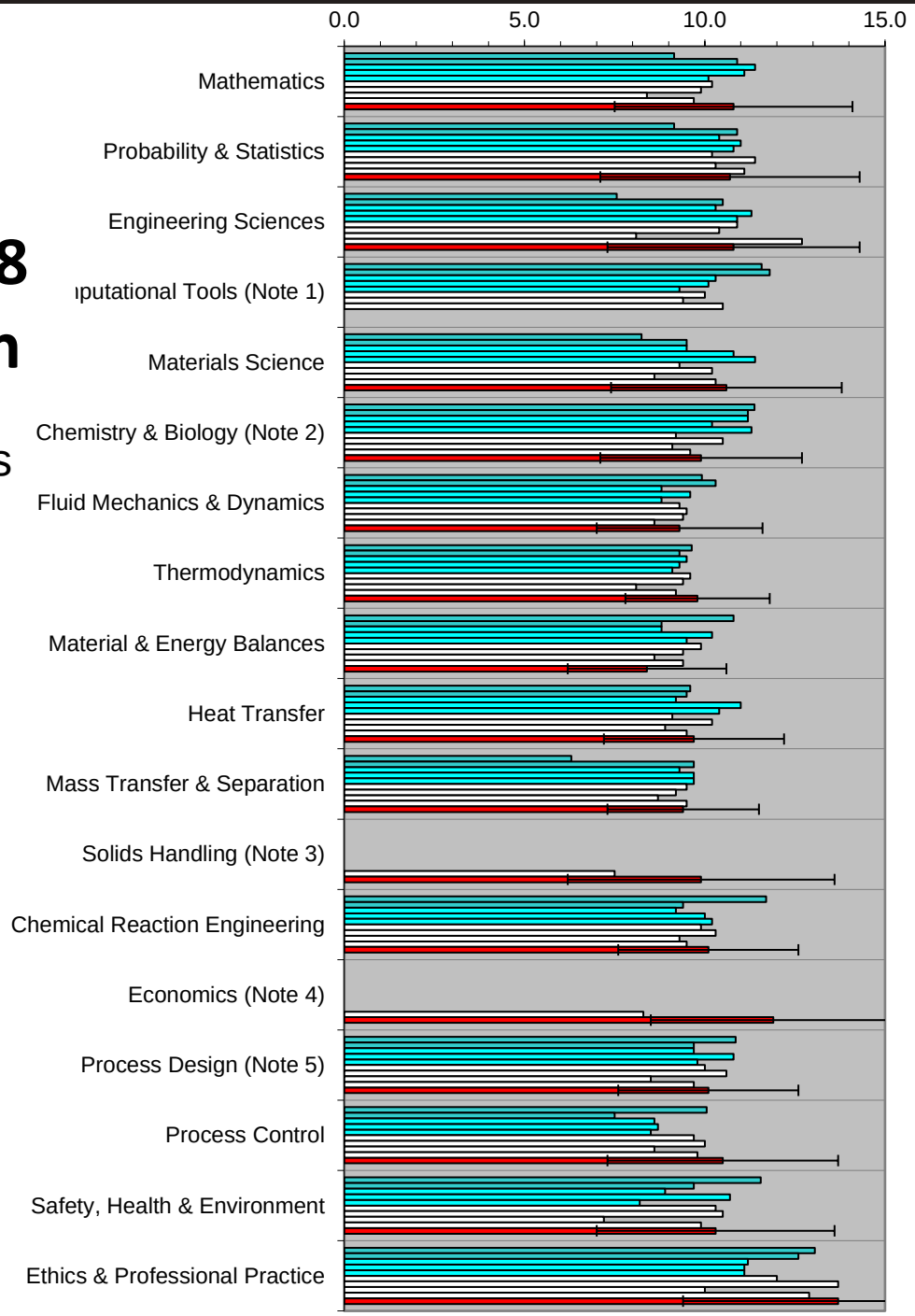
New course added in AY16 and implemented in AY19-2. Before that, scores were always very low.

Expected level of attainment is the national average (0.0 line)

Outcome 8 Evaluation

FEE Results by Topic

AY13 to AY22



The error bars are the individual standard deviations for the AY22 data.

The average standard deviation over all data is 3.0.

Year-to-year variations in the difficulty of the exam are accounted for by normalizing with respect to the national average on the next slide.

Notes:

(1) This topic dropped in 2021.
(2) "& Biology" added in 2021
(3) Economics. separated from process design in 2021.
(4) New exam spec in 2021
(5) Was Proc Design & Econ for 2020 and before

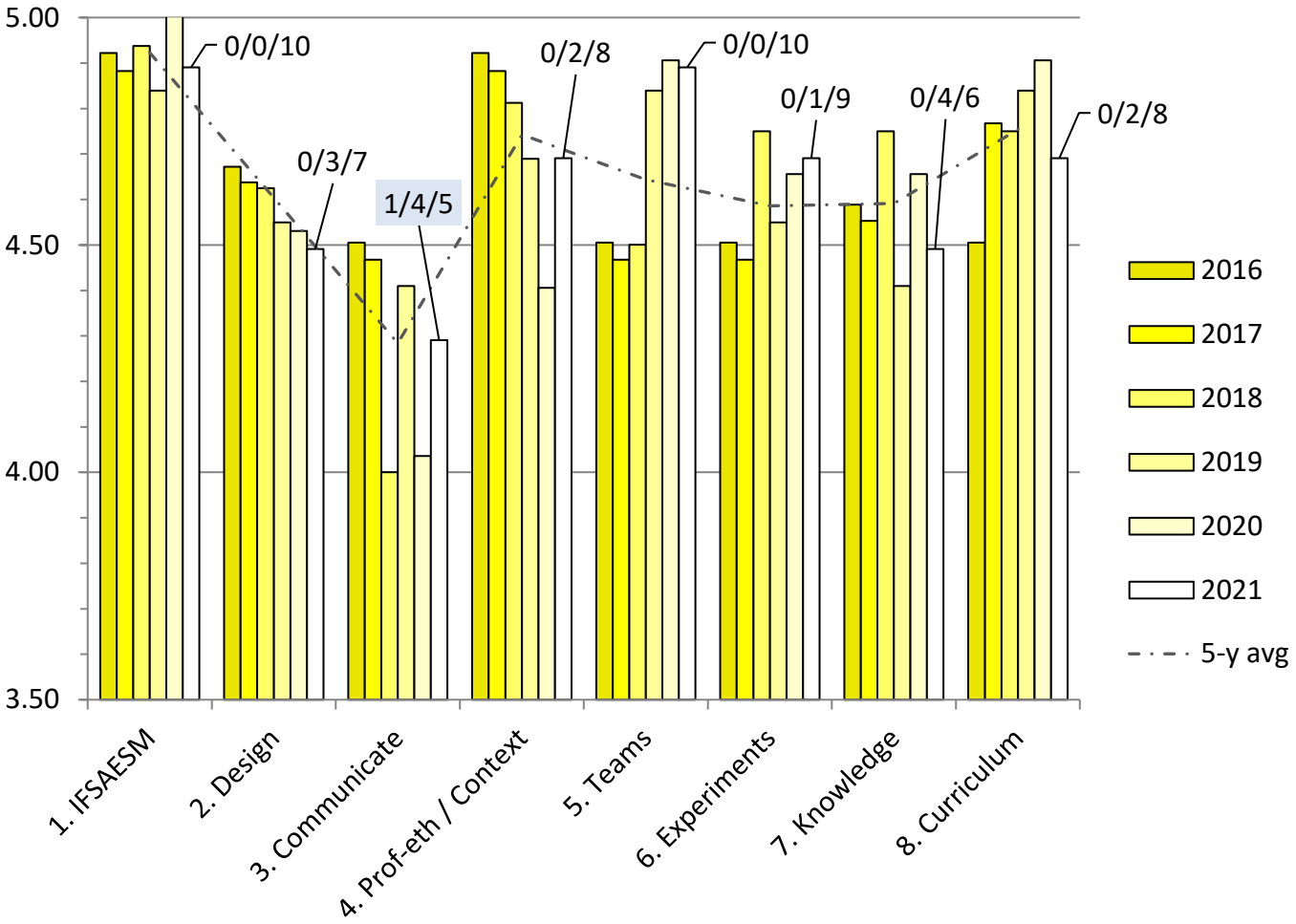
Faculty & Advisory Board Survey Results

Faculty Student Outcomes Surveys

Student Outcomes 1-8

Program Averages from AY16-21

Data labels are response frequencies on the 1-5 Survey Likert Scale (# of 3 / # of 4 / # of 5).
The average standard deviation is 0.46 and ranges from .00 to .70.

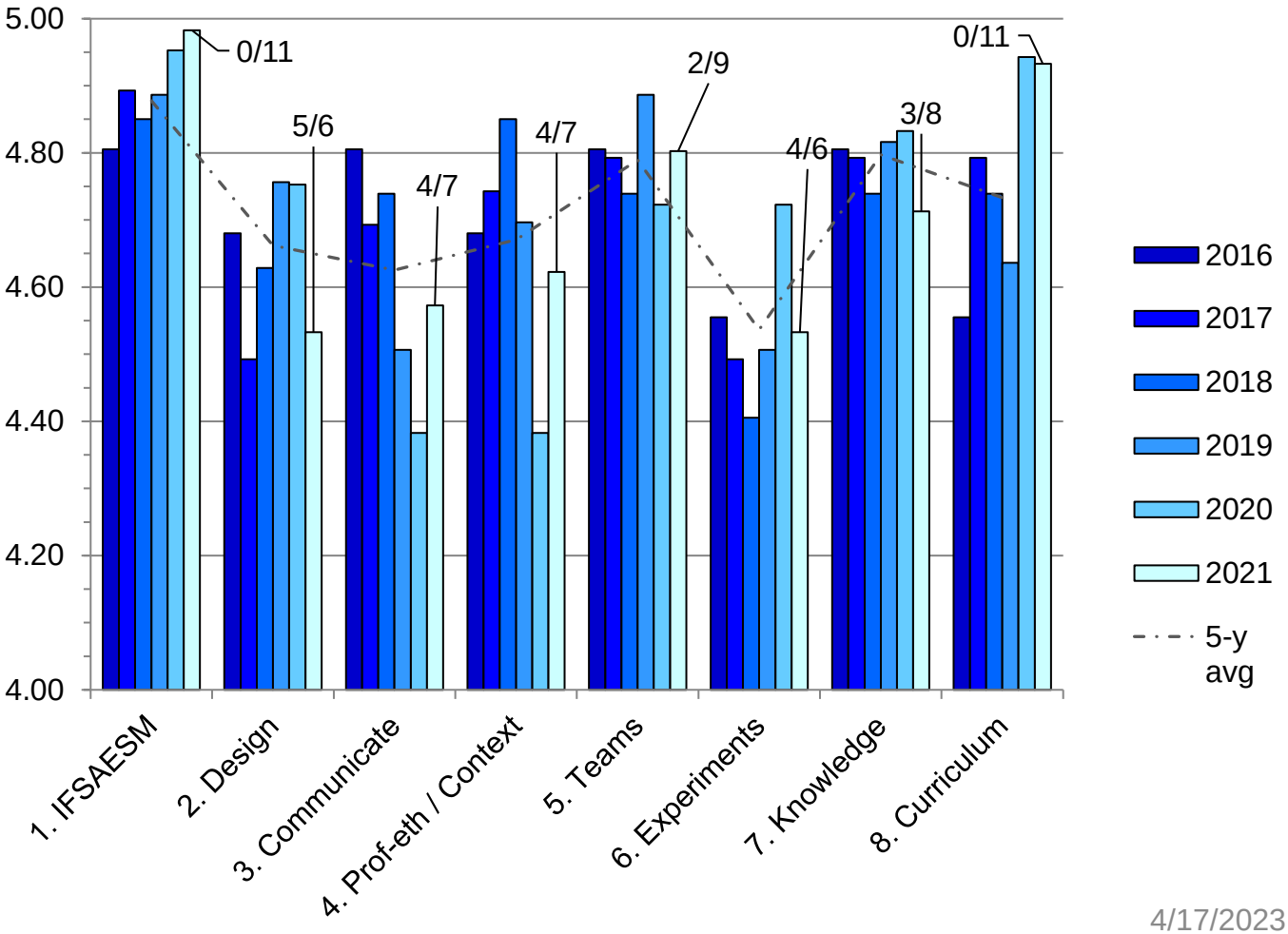


Advisory Board Student Outcomes Surveys

Student Outcomes 1-8

Program Averages from AY16-21

Data labels are response frequencies for 4 or 5 (# of 4s / # of 5s) on the 1-5 Survey Likert Scale
Standard deviations range from .00 to .52



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Advisory Board Findings

Excerpts from Minutes of 08 April 2022

- A common theme is that an earlier 1-credit course in chemical engineering is needed.
- Some method is needed to integrate concepts in EE301 to the overall curriculum.
- Second semester of organic chemistry.
- Hybrid format needs work if this is continued. Hybrid interactions were awkward.
- Provide a list of course descriptions ahead of time to the board. More guidance is needed on goals of the different parts of the meeting.
- Integrating content from courses in other departments and finding ways to integrate cadet interactions between year groups.

Future Challenges I/Discussion Points

1. **Curricular Challenges/Shortcomings/Needs Improvement**
   - **Intro to ChemE: CH200 Course (yearling year)**
   - **CH300 Measurements Lab**
   - **Second Semester of Design (CH401)**
     - **Past examples, CH400, CH485, CH365, CH367**

2. **Resource Implications**
   - **Program growth in majors**
   - **Faculty**

3. **Chemical Engineering Program Undergraduate Rankings**

Advisory Board Completes Survey Part 1

Panel for Class of 2023 and 2024 (Cows and Firsties)

Discussions with Cadets (Firsties & Cows)

1050-1120 Board ask questions of cadets. Talking points:

- Program Sustains/Improves
- Any courses in curriculum cadets are unhappy with?
- Any general issues with the program they would like to discuss?
- Any thoughts on fundamental courses preparing the cadets for upper level courses (i.e. EE301 prep for CH367, CH362 prep for pretty much everything else, ME362 prep for CH485, ME301 prep for CH365, etc.)
- Any thoughts on structure of labs associated with most courses (vice a dedicated lab course per year/semester).
- For Firsties: If you were going into the civilian job market as a new engineer, do you feel prepared?

1120-1140 Cadets ask questions of board

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Lunch – Sandwiches and Chips

Lunch:
1. Cold cut sub sandwiches (Italian/roast beef/turkey)
2. Chips: regular/barbeque/sour cream & onion/Cheetos/Doritos
3. Iced tea/lemonade/water/coffee
4. Cookies

AAR from Panel for Class of 2023 and 2024 (Cows and Firsties)

Assessment, Program Objectives and Mission/Vision Statements

USMA MISSION

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, Country

and prepared for a career of professional

excellence and service to the Nation as

an officer in the United States Army.

USMA Vision

Within an Army in transition,
West Point is the preeminent leader development and academic institution whose graduates thrive in tomorrow's complex security environments,
and are inspired to a lifetime of service to our Army and the Nation as leaders of character.

West Point is the preeminent leader development institution in the world.

Program Vision

We envision an Army that is prepared for all dimensions of modern warfare, drawing upon disciplined, highly trained chemical engineers to develop solutions to the challenges facing the nation.

Program Mission

The mission of the chemical engineering program is to prepare commissioned leaders of character who are proficient in applying chemical and engineering principles to solve problems in a complex operational environment.

Program Objectives

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

1. Demonstrate effective leadership and chemical engineering expertise.

2. Contribute to the solution of infrastructure and operational problems in a complex operational environment.

3. Succeed in graduate school or advanced study programs.

4. Advance their careers through clear and precise technical communication.

Advisory Board Recommendation + Cadet Approval

Advisory Board Completes Survey Part 2

Chemical Engineering

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3. Curriculum Updates: Bioengineering Electives

United States Military Academy
Department of Chemistry and Life Science

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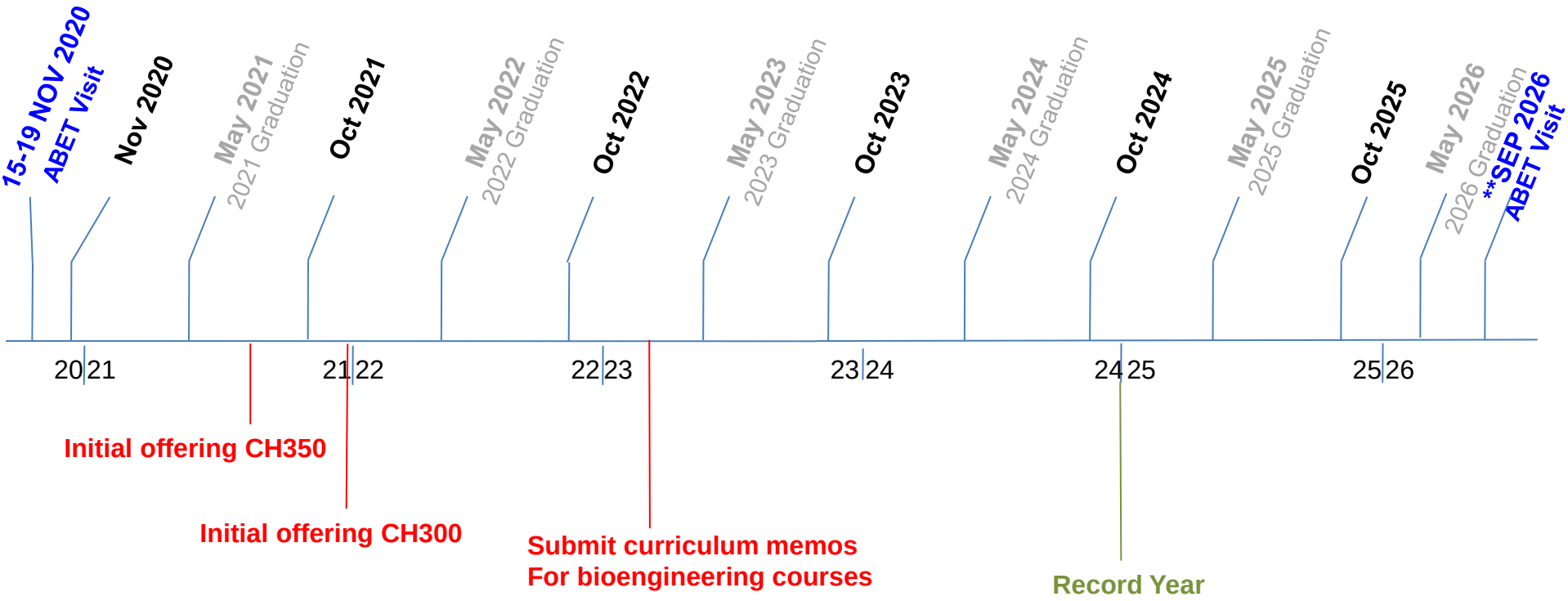
Timeline of Curriculum Updates



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Bioengineering Electives

CH300 Biomedical Engineering

- Intro to Biomedical Engr
- Cellular Org & Tissues I-III
- Organ Systems
- Biology by the Numbers
- Time in Biology
- Enzymes & Cell Cycle
- Proteins
- Bacteriophage, E. coli, Yeast
- Cellular Thermodynamics I-II
- Biological Macromolecules
- Genomes & Biotechnology Tools
- Mathematics of Water
- Statistical Biological Dynamics
- Biomedical Sensors I-II
- Biosignal Processing
- Bioelectric Phenomenon I-II
- Biomedical Transport I-II
- Bio-Imaging I-II
- Biomedical Engr Research

CH350 Bioprocess Engineering

- Cells & Biomolecules
- Enzyme Kinetics
- Central Dogma of Biology
- Kinetics
- Metabolic Regulation
- Recombinant DNA
- Protein & Metabolic Engr
- Cell Growth
- Bioreactors
- Recovery & Separation
- Animal & Plant Cells
- Medical Applications
- Industrial Applications

CH450 Bioengineering Modeling, Analysis & Design

- Biomechanics
- Biomaterials
- Tissue Engineering
- Biochemical Enzyme Kinetics & Drug Delivery
- Biochemical Engineering / Synthetic Biology
- Biosensors

Chemical Engineering

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4. Program Updates

United States Military Academy
Department of Chemistry and Life Science

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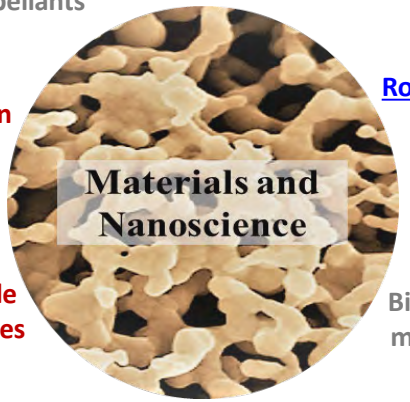
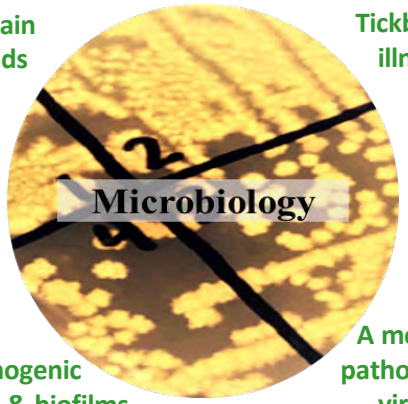
Research Areas

Blood rheology
Neuroscience
Protein aggregation
ACL injury
Public Health
3D Bioprinting & Autoimmunity
Bacteriophage

Instructional design
Laboratory design
Learning Outcomes
CWMD Operations



Propellants
Recycled polymers
Munition degradation
Robotics
Flowable electrodes
Bio-nano-materials
Field expedient batteries & energy storage



Short-chain fatty acids
Tickborne illness
DNA aptamers
A model pathogenic virus
Pathogenic bacteria & biofilms

Energy systems
Combustion systems

Toxic chemical & chemical warfare agent degradation
Nanomaterials for threat detection & mitigation
Metal Organic Frameworks
Countermeasure development
Non-linear optical applications

Program Lead: Bioengineering Chemical Engineering Chemistry Life Science

CMS: Dr. Limbocker & LTC Fallot

Research Model

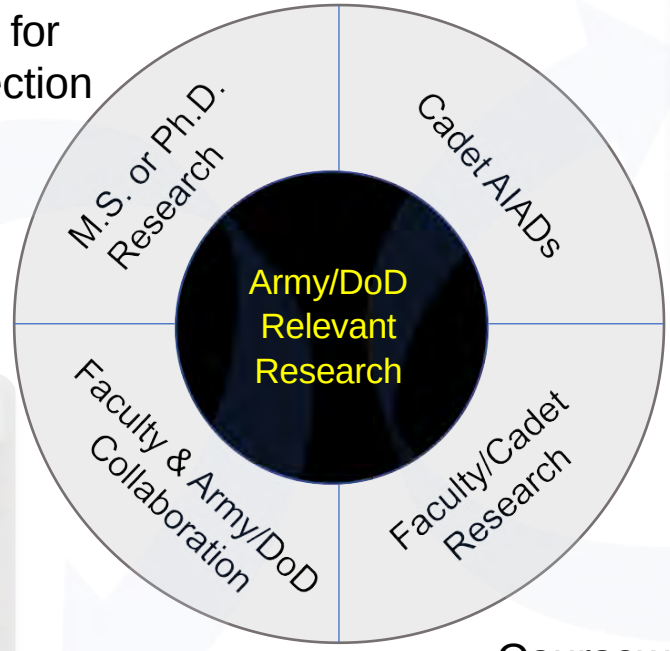
Developmental Opportunities Afforded by Faculty Research Collaboration with an Army/DoD Laboratory

Cadet Development

Mentoring for School Selection

Faculty Selection into a Discipline

Recruiting



Intellectual Capital

Faculty Development

Return to Operational Force

Coursework and Interest

Every interaction is a developmental event

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Scholarship & Excellence

Chemical Engineering Program in 2022

- **14** peer-reviewed publications
- **27** conference presentations (oral + posters)
- Scholarship winners
  - **Alexa Zammit, 2022** – MIT Lincoln Labs Fellowship and National Science Foundation Fellowship at *Massachusetts Institute of Technology*
  - **Andre Pincot, 2022** – Draper Scholar in Bioengineering at *Massachusetts Institute of Technology*

- ChemE FEE Pass Rate 1st Attempt (annual national avg ~75%)
  - AY22 (**82%**), AY21 (**75%**), AY20 (**80%**), AY19 (**88%**), AY18 (**88%**)

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CDT Alexa Zammit, '22
Chemical Engineering

- Aviation Officer
- NSF Fellow and Lincoln Labs Fellow
- Tau Beta Phi Honor Society
- Society of American Military Engineers Scholarship Winner
- Won 1st Place in Warfighter Innovation in Science and Engineering Competition
- Best Chemical Engineering/Interdisciplinary Project at USMA Projects Day
- President of AIChE
- Superintendent's Achievement Award
- Distinguished Cadet Award
- Dean's List
- FAA Private Pilot License
- Air Assault School, Battalion Commander (1st Battalion, 2nd Regiment)

Massachusetts Institute of Technology

AIAD at LANL

Fourth Class	Third Class	Second Class	First Class	Beyond
CH289/CH290	CH389/CH390	CH489/490	CH491/492	

Aviation Officer

Future Faculty

USMA Independent Research

Alexa was a part of the MFML team and has led a research team since her cow year to create conductive and high surface area biomaterials energy storage applications. Alexa has presented her research at professional scientific society and DoD conferences and has co-authored a peer reviewed journal article during her time at USMA. She was an active member of the West Point Flying Team/Aviation Club which connected her passion for materials for lightweight power research to the Aviation branch and inspired her interests in pursuing a career as an Aviation Officer. Building on her four-year research experience here at USMA, she is currently completing her MS in Materials Science at MIT through the Lincoln Labs fellowship and hopes to pursue advanced graduate studies in Materials Science through the NSF scholarship towards becoming a future faculty member in CLS.

NSF Graduate Research Fellowship Program

MIT LINCOLN LABORATORY

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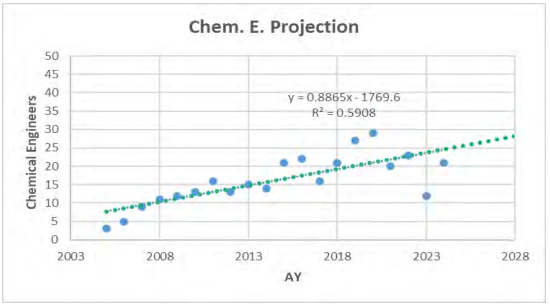
5. Future Challenges

United States Military Academy
Department of Chemistry and Life Science

Challenges Ahead

Chemical Engineering Program



1. Program Growth
- CH459 Impacts (Unit Operations Lab)

2. National Rankings for Undergraduate Programs

3. Probably the biggest factor in future challenges is our faculty allocation. Factors that affect us differently than most other schools:
- No graduate students (for TA, RA, etc.)
- No post-docs (for the majority of us)
- A large array of service obligations to USMA
- Army requirements (think ACFT, personnel actions, deployability requirements, etc.)
- Faculty allocations that are directed externally (DA level at least, if not DOD level).

4. This problem affects us every term in different ways (using Dr. Lachance, sending first-time rotators to the chemistry program, sabbaticals, etc.)

5. One option is to reduce the major to a maximum of 20 high-achieving cadets and have faculty be available to teach more than one course per semester -OR- teach one course and gain efficiency in research (and other areas).

Thank you!

- For the opportunity to show you America's Military Academy
- For your service and insights to help our program improve
- For the time you have dedicated to this visit
- For your dedication to the profession

Admin Notes for End of Meeting

- Next Advisory Board on-site
  - Early/Late April 2024…close out Class of ‘23
- Travel Paperwork/Receipts
  - DTS Voucher Mrs. Kristen Costain
- Tour of Unit Operations Lab…UTC

Extra Slides

UNITED STATES MILITARY ACADEMY
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Chemical Engineering Program Facts

ABOUT UNITED STATES MILITARY ACADEMY WEST POINT

- Founded in 1802, the first engineering school in the country
- Circa 1840: Applied Chemistry includes "preparation of..propellants & explosives and assembling them into munitions."
- Located on high ground overlooking the Hudson River in West Point,
  NY, 50 miles north of New York City
- 4294 cadet undergraduate students
- All cadets graduate with a Bachelor of Science (B.S.) degree

RESEARCH HIGHLIGHTS

- 22 On-campus Research Centers
- 10 Engineering Focused Research Centers

NOTABLE ALUMNI

- **Ben Barclay, 2016** – Lincoln Fellowship, MIT graduate, M.S. Chemical Engineering
- **Liam Comidy, 2017** – Lincoln Fellowship, MIT graduate, M.S. Chemical Engineering
- **Jesse Palmer, 2019** – Stamps Scholarship, Winston Churchill Scholar, University of Cambridge for MS in Chemical Engineering
- **Kenneth Brinson, 2019** – 4 year starter Football; 4.0; Stanford Medical School, Knight-Hennessey Scholar for MD/PhD Materials Science and Engineering
- **Anchor Losch, 2020** – Fulbright Fellowship, M.A. in Hydrodiplomacy at Tel Aviv University
- **Thomas Alvermann, 2021** - Army Health Professions Scholarship Program, MD at Dartmouth University Medical School
- **Alexa Zammit, 2022** – MIT Lincoln Labs Fellowship and National Science Foundation Fellowship at Massachusetts Institute of Technology
- **Andre Pincot, 2022** – Draper Scholar in Bioengineering at Massachusetts Institute of Technology

ABOUT DEPARTMENT OF CHEMISTRY AND LIFE SCIENCE CHEMICAL ENGINEERING PROGRAM

STUDENT ENROLLMENT

- **98** Undergraduates (AY23)

CHEMICAL ENGINEERING FACULTY

- **COL John Burpo**, Head of Department and Professor U.S. Military Academy
- **COL Corey James**, Deputy Department Head, Professor of U.S. Military Academy
- **Prof. Andrew Biaglow**, Professor of Chemical Engineering
- **Dr. Enoch Nagelli**, Associate Professor and Chemical Engineering Program Director
- **LTC Sam Cowart**, Academy Professor, Deputy Program Director
- **Dr. Simuck Yuk**, Assistant Professor
- **LTC John Belanger**, Assistant Professor
- **MAJ Jeff Chin**, Assistant Professor
- **MAJ Caspar Yi**, Assistant Professor
- **MAJ Galen Mandes**, Instructor
- **MAJ Patrick Bowers**, Instructor
- **CPT Sam Lowell**, Instructor

PROGRAM HISTORY

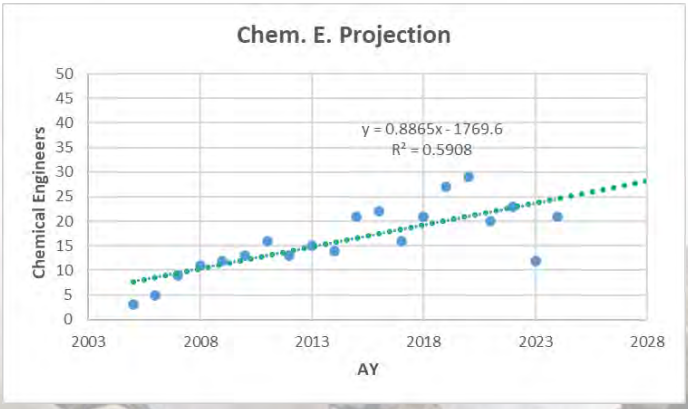
- **Begin 2002**
- **ABET Accredited 2012**
- **14 Research and industry AIADs**
- **Technical Scholarship winners**
- **Medical School**
- **Branch Demographics**
  - **Engineers**
  - **Aviation**
  - **Field Artillery**
  - **Air Defense Artillery**
  - **Infantry**
  - **Military Intelligence**
  - **Armor**

RESEARCH AREAS

- Advanced Materials
- Biochemical Engineering
- Rheology of Biomaterials
- Energy Storage and Conversion
- Complex Fluids
- Nanotechnology
- Process Control and Design
- Separations and Bioseparations
- System Modeling and Optimization
- Chemical Engineering Education
- Multi-Functional Materials

AFFILIATED RESEARCH CENTERS

- Center for Molecular Science (CMS)
- Photonics Research Center



Contact the Chemical Engineering Program:
https://westpoint.edu/academics/academic-departments/chemistry-and-life-science/chemical-engineering

Student Outcomes (new used for AY19 & beyond)

Identical to ABET 1-7 plus one additional outcome (8)

On completion of the chemical engineering program, our graduates will be able to:

1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
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. Communicate effectively with a range of audiences.
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. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.
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.

Courses Mapped to Student Outcomes (new used for AY19 & beyond)

Required Courses *	(for classes 2020 and beyond)
MA364	Engineering Mathematics
CH362	Mass & Energy Balances
CH363	Separation Processes
CH364	Chemical Reaction Engineering
CH367	Introduction to Automatic Process Control (XE472 2019 and previous)
CH485	Heat & Mass Transfer
CH459	Chemical Engineering Laboratory
CH402	Chemical Engineering Process Design
CH400	Professional Practice
ME301	Thermodynamics
ME362	Fluid Mechanics
EE301	Fundamentals of Electrical Engineering
MC300	Fundamentals of Engineering Mechanics & Design (Statics & Dynamics)
CH365	Chemical Engineering Thermodynamics
CH383	Organic Chemistry 1

***Not including prerequisites**

Chemical Engineering

United States Military Academy

Example Schedule for Chemical Engineering, Classes of 2024 and Beyond

Fall Term 4th CLASS	Course	Credit Hours	Spring Term	Course	Credit Hours
MA103	Math. Modeling & Intro. Calculus	4.5	MA104	Calculus I	4.5
CH101	General Chemistry I	4.0	CH102	General Chemistry II	4.0
EN101	Composition	3.0	EN102	Literature	3.0
HI101	The Army of the Republic	3.0	HI108	Regional Studies in World History	3.0
CY105	Introduction to Computing & IT	3.0	PL100	General Psychology	3.0
PE11x	Combatives / Boxing / Movement	0.5	MS100	Introduction to Warfighting	1.5
			PE150	Fundamentals/Personal Fitness	1.5
3rd CLASS		Total 18.0			Total 20.5
MA205	Calculus II	4.0	*CH362*	*Mass and Energy Balances*	*3.5*
PH205	Physics I	4.0	*MA364*	*Engineering Mathematics*	*3.0*
Lx203	Foreign Language	4.0	PH206	Physics II	4.0
SS201	Economics	3.0	Lx204	Foreign Language	4.0
PY201	Philosophy	3.0	SS202	American Politics	3.0
MS200	Fundamentals: Army Operations	1.5	EV203	Physical Geography	3.0
			PE 2xx	Lifetime Physical Activity	0.5
2nd CLASS		Total 19.5			Total 21.0
CH363	*Separation Processes*	*3.5*	*CH364*	*Chemical Reaction Engineering*	*3.5*
EE301	*Fundamentals of Electrical Engineering*	*3.5*	*CH367*	*Introduction to Automatic Process Control*	*3.0*
CH383	*Organic Chemistry I*	*3.5*	*ME362*	*Fluid Mechanics*	*3.5*
ME301	*Thermodynamics*	*3.5*	*MC300*	*Fundamentals of Eng. Mech. & Design*	*3.0*
PL300	Military Leadership	3.0	SS307	International Relations	3.0
MA206	Probability and Statistics	3.0	MS300	Platoon Operations	1.5
PE32x	Survival Swimming	0.5	PE360	Combat Applications	1.5
1st CLASS		Total 20.5			Total 19.0
CH459	*Chemical Engineering Laboratory*	*3.5*	*CH402*	*Chemical Engineering Process Design*	*3.5*
CH365	*Chemical Engineering Thermodynamics*	*3.0*	*CH400*	*Chemical Engineering Professional Practice*	*1.5*
CH485	*Heat & Mass Transfer*	*3.5*	*Elective*	*Engineering Elective 3*	*3.0*
Elective	*Engineering Elective 1*	*3.0*	HI302	History of the Military Art	3.0
Elective	*Engineering Elective 2*	*3.0*	LW403	Constitutional & Military Law	3.0
PE450	Army Fitness Development	1.5	MX400	Officership	3.0

Engineering Elective Tracks

Pre-approved elective sequences,
but ultimately cadet choice (can choose any 3)

Materials Engineering
MC364 Mechanics of Materials
MC380 Engineering Materials
Open Elective

Nuclear Engineering
NE300 Nuclear Reactor Analysis
NE350 Nuclear Reactor Design
NE450 Nuclear Systems Design

Decision Analysis
SE301 Foundations of Engineering Design & Systems Management
SE 481 Systems Simulation
EM484 Dynamic Systems Analysis

Advanced Control Systems
EE360 Digital Computer Logic
EM484 Dynamic Systems Analysis
XE475 Mechatronics

Energy Conversion Systems
EE377 Electrical Power Generation
ME472 Energy Conversion Systems
ME480 Heat Transfer

Power Systems
ME306 Dynamics
ME491 Mechanical Power Plants
EE377 Electrical Power Generation
XE442 Alternative Energy Engineering

Industrial Engineering
SE301 Foundations of Engineering Design & Systems Management
EM411 Project Management
EM420 Production Operations Management

Other Advanced Engineering Electives
Satisfy prerequisites
Engineering Science or design = 3.0 credits
Program director approval

ABET Criteria

- ABET Criteria changed this year, officially
  - Critical change is the reduction of dedicated engineering credit hours from 48.0 to 45.0

- Also, the Student Outcomes, what graduates of programs are expected to be able to do upon graduation, have changed
  - Fundamentally the same, but some consolidation, wording changes, and enhancements that may impact the collection of some assessment data
  - We already leaned forward to include the new SOs in our AY19 assessments, and are currently utilizing during AY20 record year.

ABET Criterion 2: Objectives

The program must have published program educational objectives that are consistent with the mission of the institution, the needs of the program's various constituencies, and these criteria.

There must be a documented, systematically utilized, and effective process, involving program constituencies, for the periodic review of these program educational objectives that ensures they remain consistent with the institutional mission, the program's constituents' needs, and these criteria.

(ABET EAC Criteria)

Program Objectives (Current Redbook)

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

1. Demonstrate effective leadership and chemical engineering expertise.

2. Contribute to the solution of infrastructure and operational problems in a complex operational environment.

3. Succeed in graduate school or advanced study programs.

4. Advance their careers through clear and precise technical communication.

Advisory Board Recommended: October 2012

Assessment Instruments for Objectives

Program Surveys

Program Advisory Board Surveys
Program Faculty Surveys
Program Cadet Surveys

UNITED STATES MILITARY ACADEMY
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Chemical Engineering Faculty

	AY22	AY23	AY24	AY25	AY26	AY27	AY28
Burpo	X	X	X	X	X	X	X
Biaglow	X	X	X	X	X		
Lachance	?	?	?	?	?	?	?
Nagelli	X	X	X	X	X	X	X
James	X	X	X	X	X	X	X
Yuk	X	X	X	X	X	X	X
Belanger		X	X	X			
Cowart	X	X	X	X	X	X	X
Armstrong	X						
Chin	X	X					
Yi	X	X					
Bowers	X	X	X				
Mandes	X	X	X				
Golonski				X	X	X	
Rogers					X	X	X
Totals	**11+**	**11+**	**8+**	**7+**	**7+**	**6+**	**6+**

a – available to teach; currently in registrar's office

? – uncertain availability

Academic Excellence

The Princeton Review

#1 Most Accessible Professors

#2 Best College Library

U.S.News & WORLD REPORT

#2 Top Public Schools (Liberal Arts)

#3 Best Undergrad Engineering Program

#4 Civil Engineering Program

#7 Mechanical Engineering Program

#19 National Liberal Arts College

Forbes.com

#1 Public College in the country

#6 Liberal Arts Universities

#11 In the Northeast

#14 Overall College in the country

UNITED STATES MILITARY ACADEMY
WEST POINT

Strategic Influence

Governmental Strategic Guidance
- President
- Congress
- Department of Defense
- Government Agencies (e.g., NSA, FBI, CIA, …)

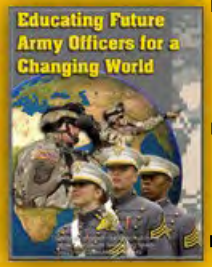
Department of the Army
- Army Goals and Priorities
- Army Regulations
- Army Doctrine

Higher Education Communities
- Professional Societies
- Accreditation Agencies
- Best Practices
- Peer Institutions

West Point Mission and Strategic Plan

Academic Program Vision and Strategic Plan

Academic Program Goals



- Core Courses
- Academic Majors
- Enrichment Experiences

Bioengineering Plans

- **Bio-Engineer Title 10 Ph.D. Spring 2020 (Dr. Yuk)**
- **Bioengineer Academy Professor Spring 2021(MAJ Corrigan)**
- **Stand up bioengineering track (1-2 years)**
  - **CH300**
  - **CH350**
- **Bioengineering sequence (2-5 years)**
- **Bioengineering minor/ major (7 – 10 years)**

UNITED STATES MILITARY ACADEMY
WEST POINT

CH300: Intro to Biomedical Engineering

CH300: Introduction to Biomedical Engineering
Course Director: COL John Burpo
Course Supervisor: Dr. Biaglow

Credit Hours: 3.0 (BS=0, ET=Under Review, MA=0)
Prerequisites: CH102, MA205
Co-requisite: None
Lessons: 30 @ 75 min
Special Requirements: None

This course provides a basis for understanding the application of engineering principles to problems in medicine and biology. It provides preparation for future graduate work in medical school, biomedical engineering, and chemical engineering. Specifically, the objectives of the course are: (1) to provide an introduction to the field and how it relates to other fields of engineering and science, (2) the develop the ability to apply mathematics, science, and engineering to solve problems, (3) to develop an understanding of the impact of engineering solutions on the medical field and society as a whole, and (4) to understand current topics within the field.

Topics – by Chapter

TEXT: Introduction to Biomedical Engineering, 3rd Edition, by John Enderle and Joseph Bronzino; Academic Press, 2012 & Physical Biology of the Cell, 2nd Ed by Rob Phillips

- *Part I: Molecular and Cellular Properties* (Ch.1, Ch.2, & Ch.3 of Enderle Text and Ch.2, Ch.3, & Ch.4 of Phillips Text)
- *Part II: Cellular Considerations* (Ch.4, Ch.5, Ch.8, and Ch.13 of Enderle Text)
- *Part III: Downstream Considerations* (Ch.10, Ch.11, Ch.12, Ch.14, Ch.15 of Enderle Text)

Course Objectives

1) Understand the broad meaning of the term "biomedical engineering" and the interface between research, engineering, and clinical fields.

2) Synthesize math, science, and engineering concepts from the Core Sequence and major courses in a biomedical engineering context.

3) Understand, apply, and manipulate models for biomedical engineering design.

4) Reinforce and strengthen conceptual and practical understanding of fundamental thermodynamics, kinetics, and mass transport.

5) Develop oral and written communication skills and continue to develop cadets' ability to prepare technical reports.

Assessment – Graded Events

6 *HWs@ 50 pts each	300	21.4%
2 *WPRs @ 200 pts each:	400	28.6%
1 *Capstone	200	14.3%
1 *TEE	500	35.7%
Total:	1400	
*Individual Points :	1400	100%

UNITED STATES MILITARY ACADEMY
WEST POINT

CH350: Bioprocess Engineering

CH350: Introduction to Bioengineering

Course Director: Dr. Simuck F. Yuk
Course Supervisor: LTC Cowart

Credit Hours: 3.0 (BS=0, ET=Under Review, MA=0)
Prerequisites: CH102, MA205, PH202
Co-requisite: None
Lessons: 30 @ 75 min
Special Requirements: None

The purpose of this course is to provide the introductory knowledge for understanding the biotechnology/bioprocessing engineering. Topic includes enzyme kinetics, molecular biology, cell growth, bioreactors, and bioprocesses. The bioprocess control and its application to different biological systems are covered in the classroom instruction. An important emphasis is made on the use of kinetics and process controls on the biological systems for engineering application.

Topics – by Chapter

Bioprocess Engineering Basic Concepts, 3rd Ed., by Michael L. Shulter, Fikret Kargi, Matthew DeLisa, Prentice Hall.

Quantitative Fundamentals of Molecular and Cellular Bioengineering, by K. Dane Wittrup, Brice Tidor, Benjamin J. Hackel, and Casim A. Sarkar, The MIT Press.

- Introduction
- Enzyme Kinetics
- Central Dogma to Molecular Biology
- Cell Growth
- Bioreactor Selection
- Bioprocess Consideration

Course Assessment – Items from Section III

Sustain:

1. Continue use of DeLisa (3rd Ed.).
2. Continue to introduce problem demos.

Improve:

1. Introduce TEE to access the cadets' understanding of course materials
2. Increase number of in-class problem demos.
3. Improve problem sets and WRPs.
4. Increase number of coding-related problems (i.e., Kinetics and Process Models).

Assessment – Graded Events

5 *Problem Sets (50pts/ea.)	250	16%
-- *Instructor Points	100	7%
1 *Capstone Design Presentation	100	7%
1 *Capstone Design Paper	200	14%
2 *WPRs	400	28%
1 *TEE	400	28%
Total:	**1450**	**100%**

UNITED STATES MILITARY ACADEMY
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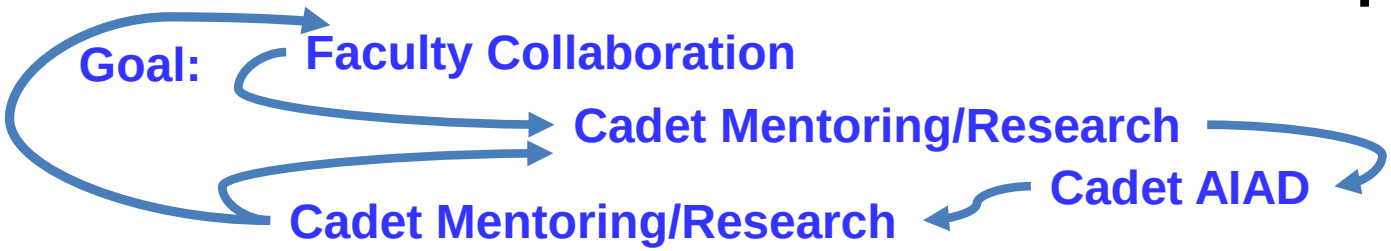
Bioengineering Track Status *as of 07APR23*

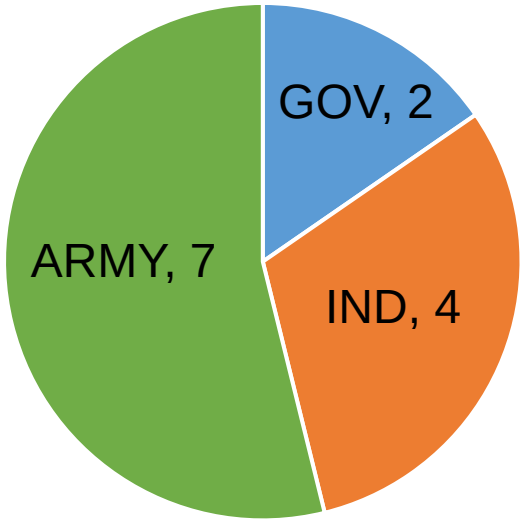
- Select Bioengineering AP (MAJ Corrigan) ✓
- Select Bioengineering T10 (Dr. Yuk) ✓
- QA/QC 3.0 ET credit for CH450 ✓
- Pilot/Teach new courses…CH350 & CH300 ✓
- **Curriculum Proposals for CH300 and CH350** ✓
  - Dr. Jones-Kellogg in AARS for pre-review ✓
  - Program internal review complete to address AARS comments ✓
  - COL Burpo & COL James Final Review/Approval before Staffing to all Depts ✓
    - Submit proposals to curriculum committee ✓
- **3.0 ET credit review process for CH300 and CH350**
  - Met with ABET Committee for ET 3.0 for CH300 and CH350 ✓
  - Internal review/revision in progress ✓
- Get courses in Redbook
- Establish Bioengineering track
- Get Bioengineering sequence approved
- ABET-compatibility (minor point)

Enrichment Opportunities

Advanced Individual Academic Development (AIAD)



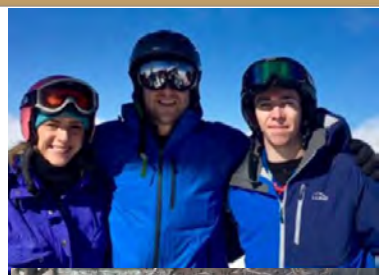
- Lawrence Livermore National Lab
- Sandia National Lab
- Army Research Labs
- Picatinny Arsenal
- BAE Systems – Radford AAP
- BAE Systems – Holston AAP
- Southern Polymer
- Uniform Color Company
- Renewable Energy Group



UNITED STATES MILITARY ACADEMY
WEST POINT

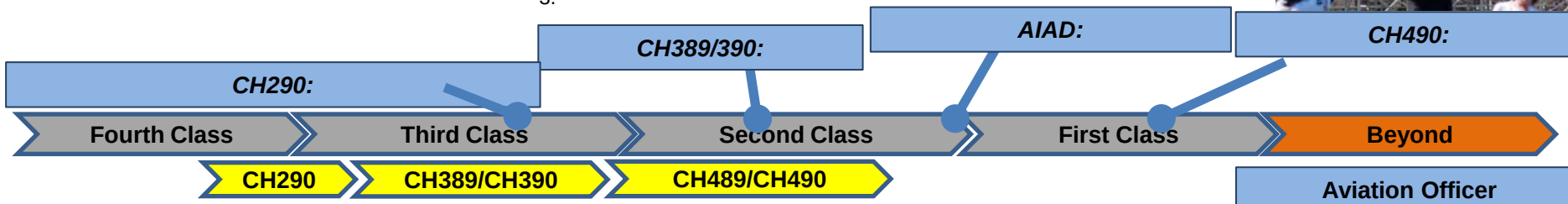
CDT Mark Jaskot, ’21
Chemical Engineering

- **Phi Kappa Phi Honor &Tau Beta Phi Honor Society**
- **Won 1st place undergraduate AIChE Materials Science and Engineering(2019)**
- **Won Physics and Nuclear Engineering Newton’s Principia Award**
- **Dean’s Pentathlete Award**



Co-Authored Conference Proceedings and Publications

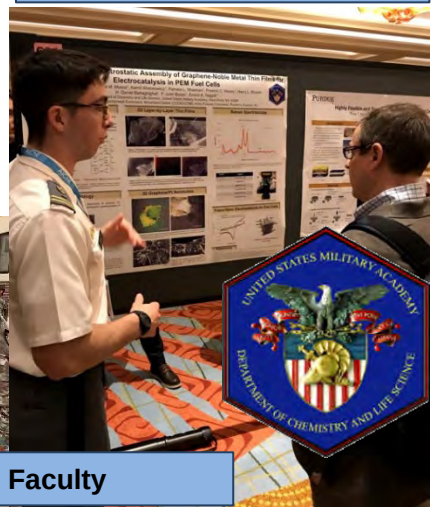
1. Won second place in research paper competition of
2. ACS Mid-Hudson Undergraduate research symposium
3.



Aviation Officer

USMA Independent Research

Cadet Jaskot has been working on a Mark has led a research team since yearling year in creating a new and inexpensive method of synthesizing lightweight catalyst materials for fuel cells. By creating this novel and scalable method of catalyst production, he hopes to drive down the cost and increase the efficiency of fuel cells, making them more realistic for vehicle, home, and grid-level applications. Mark has presented his research at national level conferences and events with the Army Research Laboratories, while also forging a collaborative relationship between his research group and the Department of Energy. The common themes of creativity, learning, and collaboration that exist between his passion for music and research are three qualities that exist in any activity that brings Mark joy.



Future Faculty

UNITED STATES MILITARY ACADEMY
WEST POINT®

CDT Matthew Dibiase, ’20
Chemical Engineering

- **Goldwater Scholarship Recipient**
- **Fullbright Scholarship Semifinalist**
- **Phi Kappa Phi Honor &Tau Beta Phi Honor Society**

Co-Authored Conference Proceedings and Publications

1. Army Research Lab (ARL) Technical Symposium “Catalysts for fuel cell electronics”. (Poster)
2. 1st Place Catalysts and Reaction Engineering, Presentation: “Nickel catalysts and graphene for lithium ion batteries”. American Institute of Chemical Engineering Annual Meeting, Orlando, FL, 10-15 NOV19.
2. Manuscript in progress, “Electroless deposition of Noble Metal Nanoparticles onto Silk Fibroin Films”, (*to be submitted, Spring 2020)*

CH290: Modeling; Rheology of Blood
CH389/390: Fuel Cell Polymers
AIAD: ARL, Nickel Based Catalysts
CH490: Functionalized Graphene

Fourth Class | **Third Class** | **Second Class** | **First Class** | **Beyond**

CH290 | **CH389/CH390** | **CH489/CH490**

Future Signal Officer

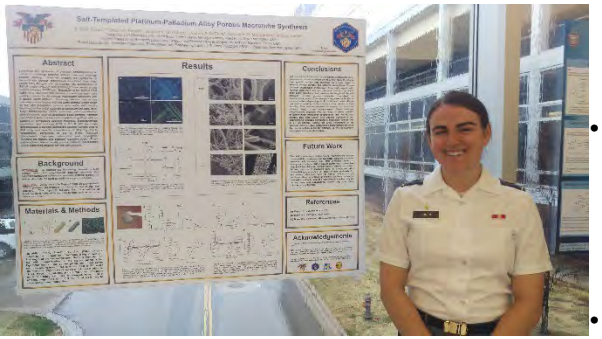
<u>USMA Independent Research</u>

Cadet Dibiase has been working on a Proton Exchange Membrane (PEM) Fuel Cell project; a field of great interest for their efficiency advantages over combustion technology. However, conventional methods of electrolysis to produce H_2 and O_2 gas necessary for PEM fuel cells rely on expensive catalysts, Pt and IrO_2. Despite exceptional efficiency of these catalysts, their high costs prevent industry scale up and production. We present alternative Ni-based catalysts to replace Pt and IrO2. Of the Ni catalysts characterized, NiS and NiFe LDH together provided the smallest total overpotentials of 1.7 V (vs SHE) for Hydrogen Evolution Reactions (HER) and Oxygen Evolution reactions (OER), respectively. However, Linear Sweep Voltammetry illustrated that NiFe LDH had the lowest overpotential of the two, contributing only 0.3 V to the total overpotential. Nevertheless, the total overpotential of 1.7 V is still only 0.2 V above the industry standard of 1.5 V from a combination of Pt and IrO_2.

Future Faculty

UNITED STATES MILITARY ACADEMY
WEST POINT®

CDT Anchor Losch, ’20
Chemical Engineering



- **Fullbright Scholarship Semifinalist**
- **Anna Sobol Levy Scholarship**
- **Rotary Scholarship – Semifinalist**
- **Tau Beta Phi Honor Society**

Co-Authored Conference Proceedings and Publications

- F. John Burpo*, **Anchor R. Losch**, Enoch A. Nagelli, Stephen J. Winter, Stephen F. Bartolucci, Joshua P. McClure, David R. Baker, Jack Bui, Alvin R. Burns, Sean F. O’Brien, Brittany Aikin, Kelsey Healy, Alexander N. Mitropoulos, J. Kenneth Wickiser, Greg Forcherio, and Deryn D. Chu “Salt-Templated Synthesis Method fo Porous Noble Metal Platinum-based Macrobeams and Macrotubes.” *J. Vis Exp*. (Invited Paper)
- Burpo, F., Nagelli, E., **Losch, A.**, Bui, J., Forcherio, G., Baker, D., McClure, P., Bartolucci, S., Chu, D. “Salt-templated Cu-Pt Alloy Macrobeams for Ethanol Oxidation.” *Catalysts*, 2019, 9(8), 662.
- Burpo, F., Nagelli, E., Bartolucci, S., Mitropoulos, A., McClure, J., Baker, D., **Losch, A.**, Chu, D. “Salt-Templated Platinum-Palladium Porous Macrobeam Synthesis.” *MRS Communications*, 2019, 9(1), 280-287.

CH289/CH290: Multi-Functional Materials

CH489: Multi-Functional Materials

Fourth Class → **Third Class** → **Second Class** → **First Class** → **Beyond**

CH290 → **CH389/CH390** → **CH489/CH490** → **Future Engineer Officer**

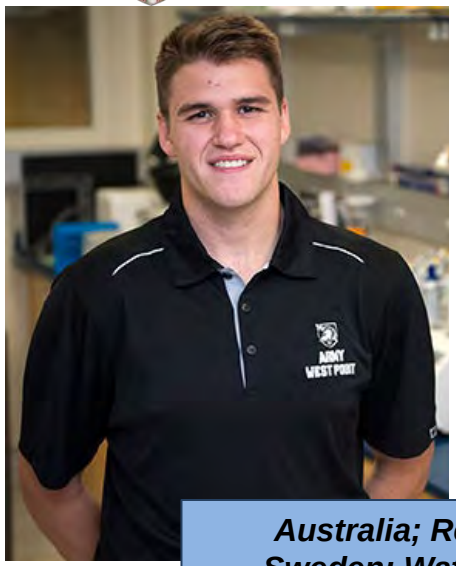
USMA Independent Research and Activities

Cadet Losch researches in the Multi-Functional Materials Laboratory. She has completed synthesis work on Salt-Templated Platinum-Palladium and Copper-Platinum Alloy Porous Macrotubes, and presented at the Inter-Academy Chemistry Symposium and Projects Day. Outside of class and research, Anchor is a conductor in the Cadet Spirit Band, and President of the Model Arab League and American Institute of Chemical Engineers. As a part of the Peace and Dialogue Leadership Initiative, she has traveled to Israel and Palestinian territories to participate in a nuanced conversation about the US role in the Middle East, with a focus on Israeli-Palestinian relations, society, and culture. She studied Arabic abroad in Morocco, where she taught English at a local NGO. She travelled to Qatar with the National Council on U.S-Arab Relations on a cultural exchange program between U.S. and Qatari servicemembers. She also has completed service work in Viet Nam, Mongolia, Papua New Guinea, and the Galapagos Islands.

Future Faculty

UNITED STATES MILITARY ACADEMY
WEST POINT®

CDT Jesse Palmer, ’19
Chemical Engineering



- **Won Stamps Scholarship**
- **Won Goldwater Scholarship**
- **Tau Beta Pi Honor Society**
- **Phi Kappa Phi Honor Society**
- **Phi Sigma Iota Society**
- **Won Churchill Scholarship**

Co-Authored Publications

1. Cellulose Nanofiber Biotemplated Palladium Composite Aerogels. *Molecules,* 23(6)
2. Gelatin biotemplated platinum aerogels. *MRS Advances*, 1-6.
3. A Rapid Synthesis Method for Au, Pd, Aerogels Via direct Solution-Based Reduction. *Journal of visualized experiments: JoVE*, (136).
4. Direct solution-based reduction synthesis of Au, Pd, and Pt Aerogels. *Journal of Materials Research*, 32(22).

Australia; Renewable Energy Lab
Sweden: Water NEXUS conference

Harvard AIAD; Disease biophysics groups

Fourth Class → **Third Class** → **Second Class** → **First Class** → **Beyond**

CH290 → **CH389/CH390** → **CH489/CH490**

USMA Independent Research

Jesse has collaborated with the Army Research Labs (ARL) in Adelphi, MD to produce biosensors and has developed novel Kevlar-cellulose composites with Harvard’s Disease Biophysics group. As a recipient of Goldwater and Stamps Scholarships Jesse has used his academic funding to attend World Water Week in Stockholm, Sweden and visit the University of New South Wales in Sydney, Australia to pursue his interest in water desalination. Jesse is also completing a minor in Eurasian Studies. He plans on attending graduate school to develop batteries to enhance prosthetic limbs serving wounded veterans.

Field Artillery Officer

Future Faculty

UNITED STATES MILITARY ACADEMY
WEST POINT

Alumni Highlight: 2LT Ellie Milanesa

-**Class of 2020, Chemical Engineer**
-**GPA:** 3.87
-**Branch:** Armor
-AIAD at Sandia National Lab
-Distinguished Cadet Award recipient
-Sandhurst Team
-**Research:** Development of materials to be used for batteries and hydrogen fuel cells. Familiarity with material synthesis as well as scanning electron microscopy (SEM), preparing electrodes, and running cyclic voltammetry and charge, discharge testing.

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Chemical Engineering Program
10+ year vision

1. **Stabilized** at **~40** +/- (1-5) cadets per class year; if >40 establish OML; Recommended GPA: ~2.3

2. Chemical engineering **faculty**:
   a. Senior faculty: AP; 2nd time rotators; Associate Professors; Title 10s; PhDs. Teach chemical engineering course 3-6 years in a row.
   b. Junior faculty: 1st time rotators. Teach CH101/102 (not both); collaborate with Senior Faculty on research. No CH102 without CH101 and teach CH362 on last year of rotation for experience in major course.
   c. Minimize churn; "Do less better."…Stability; efficiency; optimization; transparency

3. Curriculum:

Bioengineering
   a. 3x Bio.-Eng. track: CH300, CH350, CH4; validate the ET credit
   b. Stand up bioengineering sequence
   c. Stand up bioengineering major
   d. Currently: Bio.-Eng. AP search; Ongoing Title10 hiring action

Chemical Engineering:
   a. Expand CH400 to 3.0 credits
   b. Expand CH459 to 4.0 credits – cadet feedback
   c. Expand CH402 to 7.0 credits (2 sem.)
   d. Other Chem E. electives: (Numerical methods; explosives)

4. Pedagogy:
   a. Intensive problem solving with instructors as coaches and role models
   b. classroom/lab workshop experience (theory + demo + practice)
   c. faculty <u>demonstrate</u> proficiency at problem solving as well as depth of knowledge; multi-year faculty development

5. **Ranked** undergraduate program
   a. ABET recertifications (15-19 NOV20); maintain ABET efforts; assessment; strength use of SSI software/CHEMCAD
   b. Establish "footprint" at National level conferences: AIChE; SOR; ACS & communicate USMA Chem. E. vision to other Universities
   c. Get more Chemical Engineers PEV training here (James, Nagelli)
   d. **Maintain** BH331 computer room; chemical engineering work/research space (Applications Rm.; BH136); Network

6. AIChE Club stability…and consistency of student involvement; strength of last ABET certification in 2014