AY22-1 Chemical Engineering Course and Program Brief

LTC Matthew Armstrong

LTC Sam Cowart
MAJ Trevor Corrigan

MAJ Jeff Chin

Dr. Enoch Nagelli

Dr. Andy Biaglow
Dr. Simuck Yuk

CPT(P) Yi

15APR21

Agenda

- Course Briefings
  - -CH485
  - -CH363
  - -CH365
  - -CH459
  - -CH350
- Getting back to normal
- Bioengineering
- ABET and Advisory Board Update

CH485: Heat and Mass Transfer
Course Director: LTC Sam Cowart

Credit Hours: 3.5 (BS=0, ET=3.5, MA=0)
Prerequisites: MA364 and MC312
Co-requisite: None
Lessons: 30 @ 75 min, 7 @ 120 min
Special Requirements: None

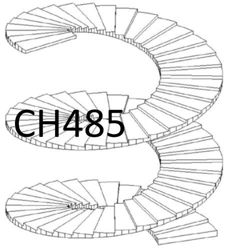
This course includes the study of the mechanisms of energy and mass transport, with special emphasis on applications in engineering systems. Coverage includes Fourier's Law of Heat Conduction, and Fick's Law of Diffusion, the development of shell energy and species balances, and the use of these equations 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 design.

Topics

Mass and Heat Transfer, T.W. Fraser Russell, A.S. Robinson, and N.J. Wagner, Cambridge University Press, Copyright 2008

- Introduction (1 Lesson)
- Macroscopic mass, energy, and species balances
  - Chemical reactors (2 lessons)
  - Heat exchangers (5 lessons)
  - Mass contactors (4 lessons)
- Microscopic mass, energy, and species balances
  - Conduction and diffusion (9 lessons)
  - Convective heat and mass transfer (7 lessons)
  - Heat Exchanger Design - CHEMCAD (2 lessons)

Course Assessment – Items from Section III



<u>Sustain</u>:

Problem solving days prior to WPR/ICPS

Lesson structure & content

<u>Improve</u>:

- Revise Problem Sets – Too much reliance on old solutions
- Incorporate more example problems into lesson material
- Changes to Lab 3 & 7
  - 1-D conduction in different materials w/ CFD solver(Lab3)
  - Viscous, thermal, diffusive boundary layer effects w/ CFD solver (Lab 7)

Assessment – Graded Events

8 Problem Sets @ 30 or 50 pts each:	340	16%
2 *In-Class Prob. Sets @ 100 pts each:	200	9%
3 *WPRs @ 200 pts each:	600	28%
1 *Writing Assignment @ 200 pts:	225	11%
7 Labs @ 40 pts each:	280	13%
1 *Term End Exam @ 500 pts:	500	23%
Total:	2110	
*Individual Points :	1525	71%

CH363: Separations Processes

Course Director: LTC Matthew Armstrong

Credit Hours: 3.5 (BS=0, ET=3.5, MA=0)
Prerequisites: CH362
Co-requisite: None
Lessons: 30 @ 75 min, 7 @ 120 min
Special Requirements: None

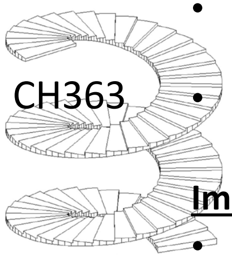
This course covers methods for the physical separation of chemicals. Topics include dew point and bubble point calculations, adiabatic flash, distillation, chromatography, liquid-liquid and gas-liquid absorption/stripping. Students are taught the significance of staging of unit operations. Heavy emphasis is placed on theory of operations, numerical methods of solution, and simulation.

Topics – by Chapter

Separation Process Principles, 4th Ed., by J.D. Seader, E.J. Henley and D.K. Roper

- Introduction to Separations/DOF Analysis (Ch. 1)
- Vapor-liquid, gas-liquid, solid-liquid, flash(Ch. 4)
- Cascading configurations (Ch. 5)
- Designing trayed towers and packed columns (Ch. 6)
- Optimizing towers and columns (Ch. 7)
- Liquid-liquid extraction (Ch. 8)
- Multi-component distillation (Ch. 9)
- Capstone Project

Course Assessment – Items from Section III



Sustain:

- Technical Writing: Written Research Paper
- Capstone project – Ties all key concepts together. Assesses communication outcome.
- ChemCAD use in concert with theory/ every day CHEMCAD

Improve:

- Need extra distillation lesson in block 3; topic needs more treatment and fits better in block 3
- Improve cadets reliance on the text as a resource
- **More** instructor problems for HW/ less book problems

Assessment – Graded Events

8 Problem Sets @ 40 pts each:	320	13.3%	
4 *In-Class Prob. Sets @ 75 pts each:		300	12.5%
3 *WPRs @ 200 pts each:		600	25.0%
1 *Research Paper @ 100 pts:	100	4.2%	
7 *Labs @ 40 pts each:		280	11.6%
1 *Term End Exam @ 500 pts:	500	20.8%	
1 *Capstone		300	12.5%
Total:		2400	
*Individual Points :		1820	75.8%

CH365: Chemical Engineering Thermodynamics
Course Director: Dr. Biaglow

Credit Hours: 3.0 (BS=0, ET=3.0, MA=0)
Prerequisites: CH363, CH364, MA366, MC312
Co-requisite: None
Lessons: 40 @ 55 min
Special Requirements: None

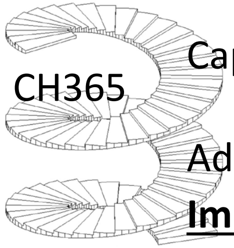
This course covers the body of thermodynamic knowledge necessary for understanding modern chemical process simulation. Students learn the theory behind the thermodynamic methods used in the software. The course includes calculus- and numerical-based thermodynamics approaches for determining the properties 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.

Topics – by Chapter

Chemical Engineering Thermodynamics, Smith, van Ness, Abbott, and Swihart, 8th Edition (2018)

- Introduction (Ch. 1)
- First Law (Ch. 2)
- Equations of State (Ch. 3)
- Heat (Ch. 4)
- Entropy and Second Law (Ch. 5)
- Fluid Properties (Ch. 6)
- Equilibrium (Ch. 10)
- Solution Thermodynamics (Ch. 11)

Course Assessment – Items from Section III



Sustain:

Writing project - resume exercise involved intense use of instructor time but positive changes were observed; many teachable moments

Capstone project – calculation of properties and comparison with CAD

Addition of writing to capstone

Improve:

More emphasis on Ch 11, specifically excess properties

More practice on calculating fugacity and activity.

Use of writing rubric to assess capstone.

Assessment – Graded Events

1 *Term End Exam @ 500 pts:	500	22.42%
1 *Capstone Design Project @ 300 pts	300	13.45%
3 *Capstone IPRs @ 30 pts each:	90	4.04%
3 *WPRs @ 200 pts each:	600	26.91%
64 *Problems @ 10 pts each:	640	28.70%
1 *Writing Assignment @ 100 pts:	100	4.48%
Total:	2230	100.00%
*Individual Points :	2230	100%

CH459: Chemical Engineering Lab
Course Director: Dr. Enoch Nagelli

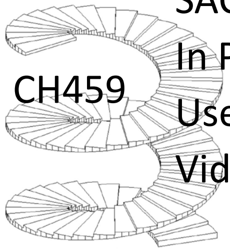
Credit Hours: 3.5 (BS=0, ET=3.5, MA=0)
Prerequisites: CH362/CH363/CH364
Co-requisite: None
Lessons: 40 @ 120 min, 7 @ 120 min
Special Requirements: None

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.

1. *Unit Operations of Chemical Engineering*, 7th Edition, by Warren L. McCabe, Julian C. Smith and Peter Harriott; McGraw-Hill, 2005.
2. *Plant Design and Economics for Chemical Engineers* 5th ed., Peters, Max S. and Klaus D. Timmerhause, McGraw-Hill, New York 2003, ISBN-10: 0071240446

1. Batch and CSTR — EC: Short HtExchgnr
2. Cooling Tower
3. Hydrogen Fuel Cell
4. Single/Double Effect Evaporator
5. Distillation
6. Carbon Dioxide Absorber

Course Assessment – Items from Section III



Sustain:

Technical Writing: Written Lab Reports/ Posters/ Executive Sum.

SACHE Modules

In Progress Reviews (IPRs)

Use of CHEMCAD to model all lab data

Videos of each experiment for cadets to develop procedure

Improve:

Balance of work on teams; assign roles for each cadet and rotate

Individual CHEMCAD

Assessment – Graded Events

6 Lab HWs@ 20 pts each	120*	4.9%
6 Lab Exec. Sum/ Poster/ Report	600	24.8%
6 IPRs @25 pts ea	150	6.2%
6 Lab Execution (aka. lab rubric)	450	18.6%
2 *WPRs @ 550 pts each:	1100*	45.5%
Total:	2420	
*Individual Points :	1220	50.4%

CH350: Introduction to Bioengineering

Course Director: Dr. Simuck Yuk

Credit Hours: 3.0 (BS=0, ET=3.0, MA=0)
Prerequisites:
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.

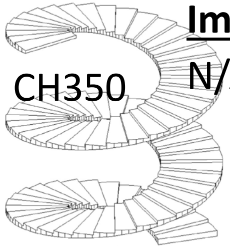
Quantitative Fundamentals of Molecular and Cellular Bioengineering, by K. Dane Wittrup, Brice Tidor, Benjamin J. Hackel, and Casim A. Sarkar, The MIT Press.

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

Course Assessment – Items from Section III

Sustain:

N/A at this point.



Improve:

N/A at this point.

Assessment – Graded Events

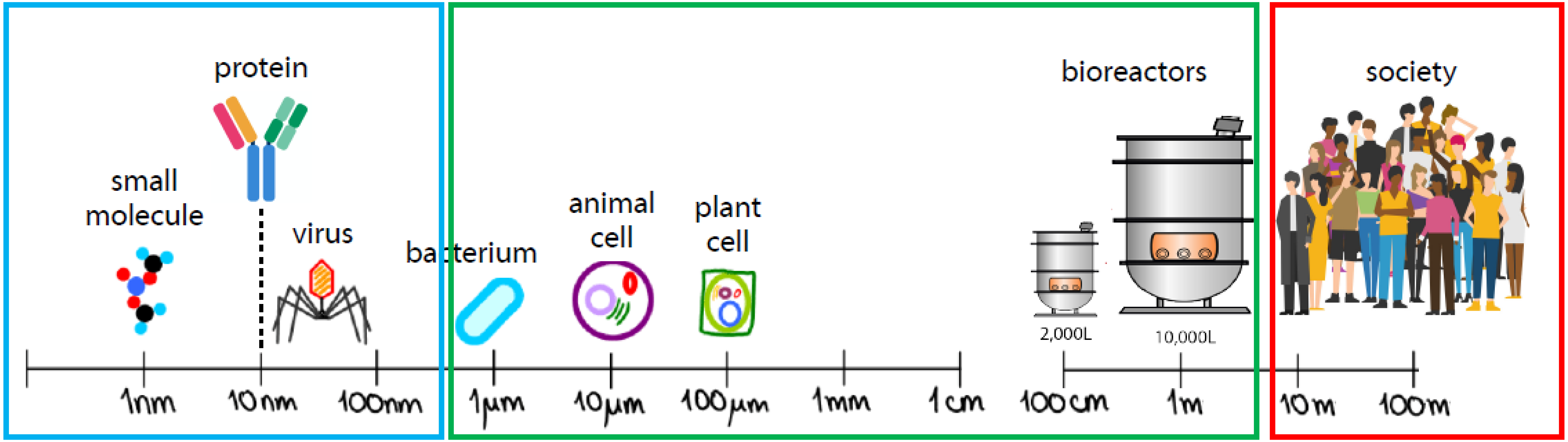
1 *Capstone Presentation	100	9%
1 *Capstone Paper	200	18%
2 *WPRs	400	36%
5 Problem Sets(50pts/ea.)	250	23%
1 *Discussion	150	14%
Total:	1100	100.00%

Getting back to normal

- Transition back to 100% in person class AY22-1?; FDW Summer
- AI in person
- Submitting abstracts to Society of Rheology and AIChE Annual Conference
- Project Day in person
- Meeting new chemical engineering Plebes in person
- Hard copies for assignment turn in
- In person research is in progress; wet labs up and running;

CH350 Course Layout

Molecular – Cellular – Bioreactor/Purification Systems – Societal



Block 1 - Biomolecular Considerations 12 lectures (plus 1 WPR)
LSN 1-13

Block 2 - Cellular Considerations 8 lectures (plus 1 WPR)
LSN 14 - 22

Block 3 - Downstream Considerations 6 lectures (Plus 2 lessons of Group Presentations)
LSN 23-30

CH350 Detailed Overview

- **Textbook:**
  1. *Bioprocess Engineering Basic Concepts,* 3rd Ed., by Michael L. Shulter, Fikret Kargi, Matthew DeLisa, Prentice Hall.
  2. *Quantitative Fundamentals of Molecular and Cellular Bioengineering,* by K. Dane Wittrup, Brice Tidor, Benjamin J. Hackel, and Casim A. Sarkar, The MIT Press.

- **Major Blocks:**
  1. Biomolecular considerations: enzyme kinetics and molecular biology
  2. Cellular considerations: cell growths and process considerations of bioreactor development
  3. Downstream considerations: bioprocess development in different cell cultures

CH350 Detailed Overview

CH350 - Bioprocess Engineering (AY 22-1)

2-Days during X2-hr (XXXX-XXXX) in BH331 Text: Bioprocess Engineering: Basic Concepts, 3rd Ed., Shuler, Kargi & DeLisa

Day	2-Day	LSN	Subject	Reading	Instructor	Event	Points
			Block I: Biomolecular Considerations				
Th	21-Jan	1	Introduction to Bioprocess Engineering	Ch 1 (Schuler et al)	Dr. Yuk		
M	25-Jan	2	Introduction to Cells and Biomolecules Part 1	Ch 2.1 (Schuler et al)	Dr. Yuk		
Th	28-Jan	3	Introduction to Cells and Biomolecules Part 2	Ch 2.2-2.3 (Schuler et al)	Dr. Yuk	Problem Set 1 Due	50/50
M	1-Feb	4	Enzyme kinetics and immobilized enzyme systems Part 1	Ch 3.1-3.2.3.1 (Schuler et al)	Dr. Yuk		
F	5-Feb	5	Enzyme kinetics and immobilized enzyme systems Part 2	Ch 3.2.3.2- 3.2.6 (Schuler et al) Skim: MIT Press Chap 3.3	Dr. Yuk	Discussion Grade 1	30/80
Tu	9-Feb	6	Enzyme kinetics and immobilized enzyme systems Part 3	Ch 3.3 (Schuler et al)	Dr. Yuk		
Th	11-Feb	7	Non-covalent binding interactions; Binding equilibria and kinetics	MIT Press Chap 2.1-2.4	Dr. Yuk	Problem Set 2 Due	50/130
Tu	16-Feb	8	Central dogma of molecular biology	Ch 4 (Schuler et al)	Dr. Yuk		
Th	18-Feb	9	Genetic/metabolic regulation	Ch 5 (Schuler et al)	Dr. Yuk		
M	22-Feb	10	Recombinant DNA technology / Heterologous protein expression	Ch 8 (Schuler et al)	Dr. Yuk	Problem Set 3 Due	50/180
F	26-Feb	11	Protein engineering	Li, C. et al (Article)	Dr. Yuk		
Tu	2-Mar	12	Metabolic engineering	Varma, A et al (Article)	Dr. Yuk	Discussion Grade 2	30/210
Th	4-Mar	13	WPR I		Dr. Yuk	WPR 1	200/410
			Block II: Cellular Considerations				
Tu	9-Mar	14	General concepts of cell growth - Part 1	Ch 6.1 (Schuler et al)	Dr. Yuk		
F	12-Mar	15	General concepts of cell growth - Part 2	Ch 6.2-6.4 (Schuler et al)	Dr. Yuk		
Tu	16-Mar	16	General concepts of cell growth - Part 3	Ch 7 (Schuler et al)	Dr. Yuk	Problem Set 4 Due	50/460
Th	18-Mar	17	Operational Considerations for Bioreactors: Suspension and Immobolized Cultures	Ch 9.1-9.3 (Schuler et al)	Dr. Yuk	Discussion Grade 3	30/490
M	22-Mar	18	Bioreactor selection, scale-up and process control Part 1	Ch 9.4-10.1 (Schuler et al)	Dr. Yuk		
F	26-Mar	19	Bioreactor selection, scale-up and process control Part 2	Ch 10.2-10.4 (Schuler et al)	Dr. Yuk	Problem Set 5 Due	50/540
W	31-Mar	20	Upstream operational challenges and other biomanufacturing considerations		Professor DeLisa		
F	2-Apr	21	Guest Lecture - Erin Johnson (MERK) Up Stream Processing		Erin Johnson		
F	9-Apr	22	WPR II		Dr. Yuk	WPR 2	200/740
			Block III: Downstream Considerations				
Tu	13-Apr	23	Product recovery and separation - Part 1	Ch 11.1-11.3 (Schuler et al)	Dr. Yuk		
Th	15-Apr	24	Product recovery and separation Part 2	Ch 11.4-11.7 (Schuler et al)	Dr. Yuk		
M	19-Apr	25	Bio Process Considerations using Animal Cells	Ch 12 (Schuler et al)	Dr. Yuk	Discussion Grade 4	30/770
Th	22-Apr	26	Bio Process Considerations using Plant Cells	Ch 13 (Schuler et al)	Dr. Yuk		
M	26-Apr	27	Medical Applications of Bioprocess Engineering	Ch 15 (Schuler et al)	Dr. Yuk		
F	30-Apr	28	Traditional Industrial Bioprocesses	Appendix A (Schuler et al)	Dr. Yuk	Discussion Grade 5	30/800
Tu	4-May	29	Capstone Presentations		Dr. Yuk	Capstone Paper	200/1000
M	10-May	30	Cadet Presentations		Dr. Yuk	Capstone Presentation	100/1100
			TEE Week of 12-15 DEC 2021			TOTAL POINTS	1100

PS's	250
WPR's	400
DG's	150
Paper	200
Pres	100
TOTAL	1100

FDW for CH350 (Term 22-1)

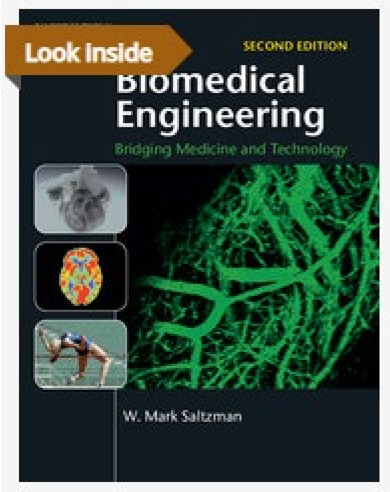
- FDW Mentor: Chemical Engineering senior faculty
- FDW Mentee: Dr. Simuck Yuk
- Working Timeline:
  - On-going: individual preparation and course administration prep
  - 1JUN: IPR
  - Summer 2021: 31MAY – 11JUN (4-6 practice lessons)
  - Lessons: x lessons…
    - Lesson w:
    - Lesson x:
    - Lesson y:
    - Lesson z:

Bioengineering

- Need to get Curriculum Memoranda completed and approved by Curriculum Committee for CH300 & CH350
- Need to QA/QC the 3.0 ET content from Dr. Tamm
- Bioengineering track
- 3-course engineering sequence
- Bioengineering minor (2-3 years)
- Bioengineering major (5 – 15+ years); ABET accredited ~2030

Dept Head Decisions/Staffing

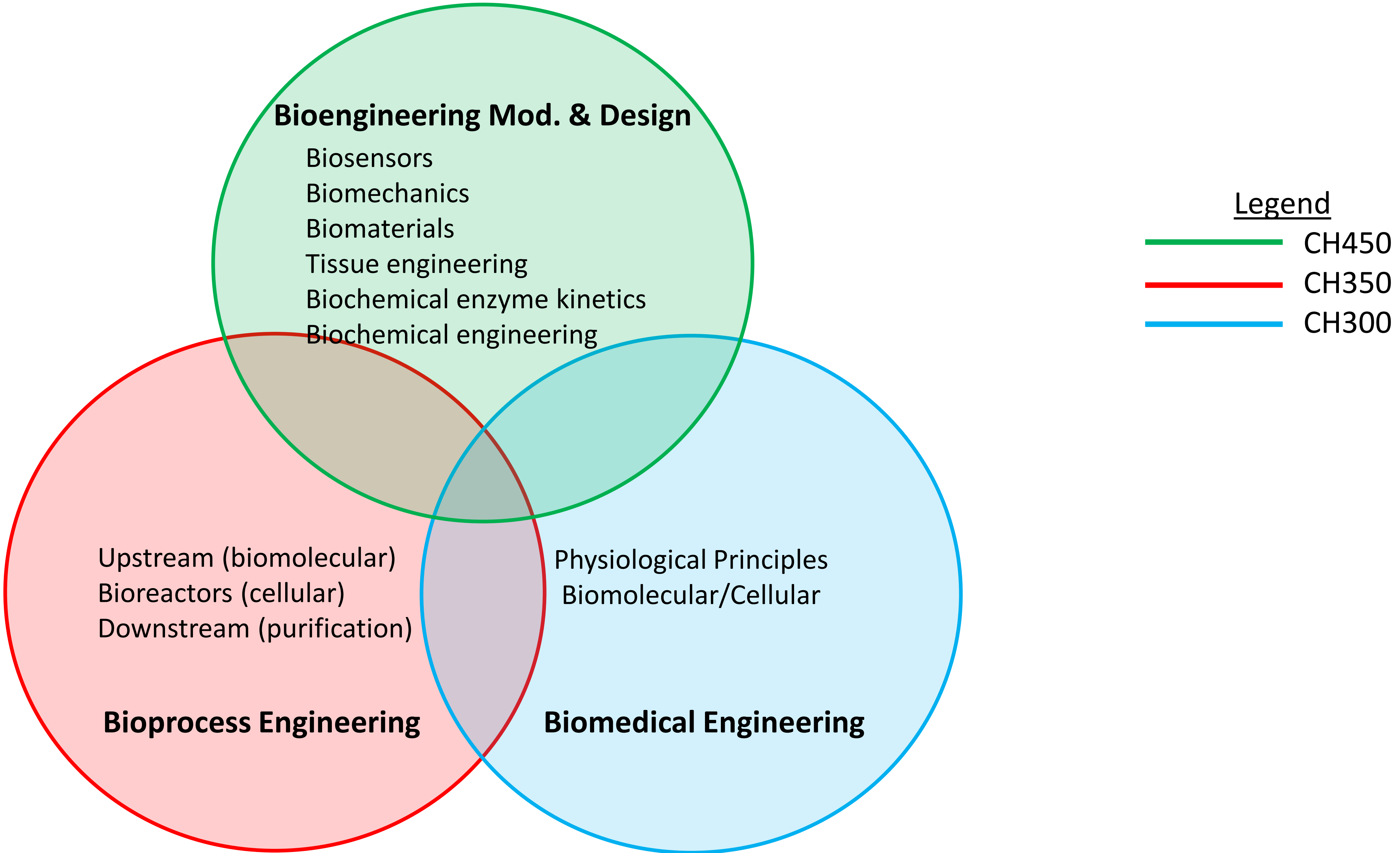
- Textbook approval for CH300
- Lesson Sequence Concept Selection CH300 (COA 1, COA2 or hybrid)
- Submit for ET credit for CH350 this summer? Or wait?
- Submit CH300 for ET Credit Approval (Dr. Tamm) this summer?
- Submit for formal Course approval by Academic board next June for both CH300/CH350?



<u>Staffing Due Outs</u>

- Memo for ET credit CH350/CH300 (use CH450 as an example)
- Curriculum committee approval for addition of BME to transcript
    - Example of History majors
    - Mech majors historically
- Memo's for curriculum committee permanent course approval

COA1 - Bioengineering Venn Diagram



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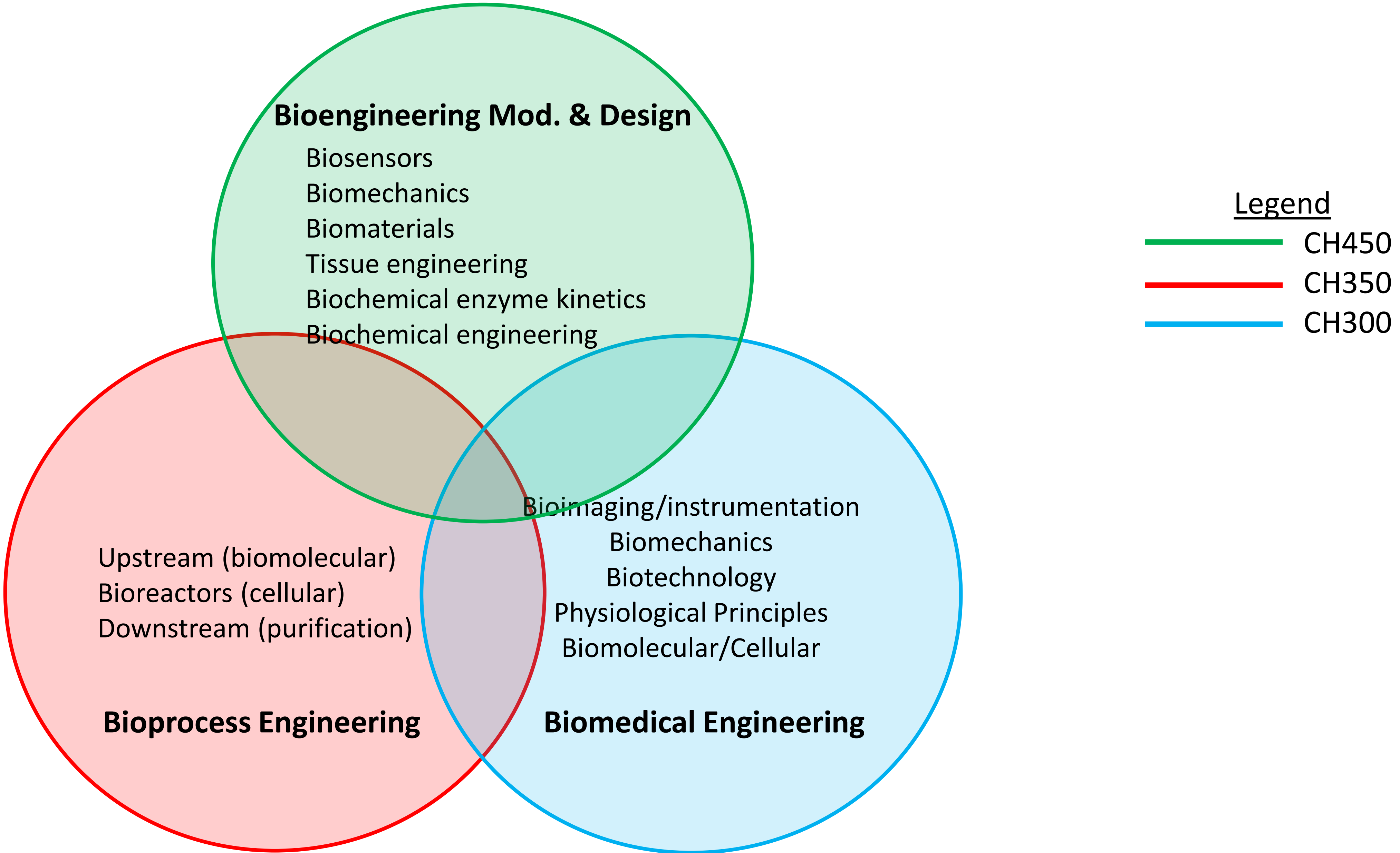
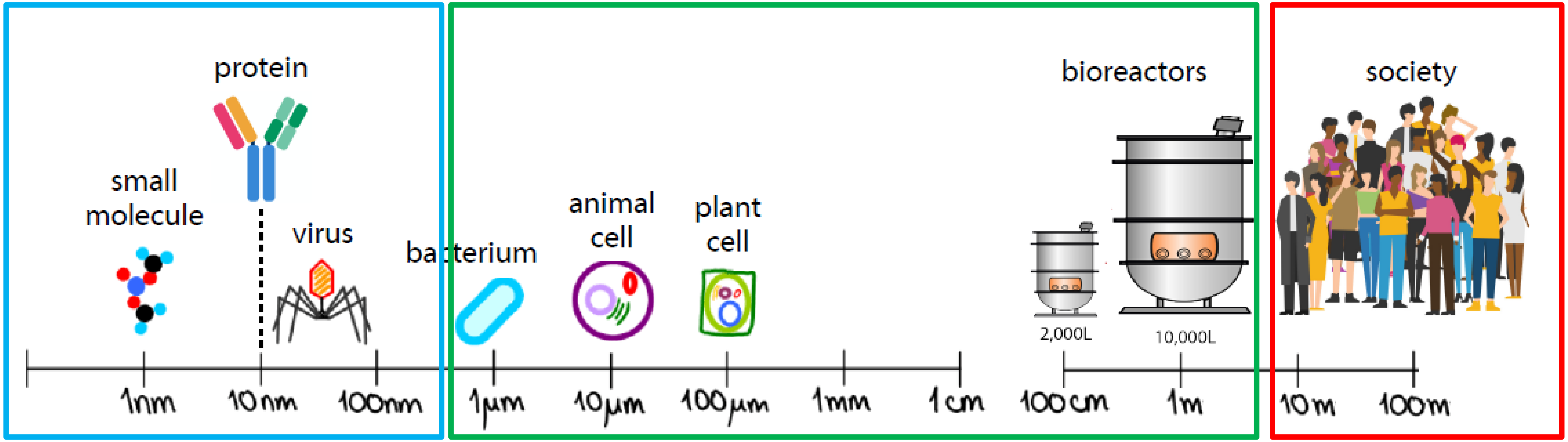
COA2 - Bioengineering Venn Diagram



CH350 Course Layout

Molecular – Cellular – Bioreactor/Purification Systems – Societal



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LSN 1-13

Block 2 - Cellular Considerations 8 lectures (plus 1 WPR)
LSN 14 - 22

Block 3 - Downstream Considerations 6 lectures (Plus 2 lessons of Group Presentations)
LSN 23-30

CH350 Detailed Overview – Syllabus

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CH350 - Bioprocess Engineering (AY 22-1)

2-Days during X2-hr (XXXX-XXXX) in BH331 Text: Bioprocess Engineering: Basic Concepts, 3rd Ed., Shuler, Kargi & DeLisa

Day	2-Day	LSN	Subject	Reading	Instructor	Event	Points
			Block I: Biomolecular Considerations				
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M	25-Jan	2	Introduction to Cells and Biomolecules Part 1	Ch 2.1 (Schuler et al)	Dr. Yuk		
Th	28-Jan	3	Introduction to Cells and Biomolecules Part 2	Ch 2.2-2.3 (Schuler et al)	Dr. Yuk	Problem Set 1 Due	50/50
M	1-Feb	4	Enzyme kinetics and immobilized enzyme systems Part 1	Ch 3.1-3.2.3.1 (Schuler et al)	Dr. Yuk		
F	5-Feb	5	Enzyme kinetics and immobilized enzyme systems Part 2	Ch 3.2.3.2- 3.2.6 (Schuler et al) Skim: MIT Press Chap 3.3	Dr. Yuk	Discussion Grade 1	30/80
Tu	9-Feb	6	Enzyme kinetics and immobilized enzyme systems Part 3	Ch 3.3 (Schuler et al)	Dr. Yuk		
Th	11-Feb	7	Non-covalent binding interactions; Binding equilibria and kinetics	MIT Press Chap 2.1-2.4	Dr. Yuk	Problem Set 2 Due	50/130
Tu	16-Feb	8	Central dogma of molecular biology	Ch 4 (Schuler et al)	Dr. Yuk		
Th	18-Feb	9	Genetic/metabolic regulation	Ch 5 (Schuler et al)	Dr. Yuk		
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Th	4-Mar	13	WPR I		Dr. Yuk	WPR 1	200/410
			Block II: Cellular Considerations				
Tu	9-Mar	14	General concepts of cell growth - Part 1	Ch 6.1 (Schuler et al)	Dr. Yuk		
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Tu	16-Mar	16	General concepts of cell growth - Part 3	Ch 7 (Schuler et al)	Dr. Yuk	Problem Set 4 Due	50/460
Th	18-Mar	17	Operational Considerations for Bioreactors: Suspension and Immobolized Cultures	Ch 9.1-9.3 (Schuler et al)	Dr. Yuk	Discussion Grade 3	30/490
M	22-Mar	18	Bioreactor selection, scale-up and process control Part 1	Ch 9.4-10.1 (Schuler et al)	Dr. Yuk		
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W	31-Mar	20	Upstream operational challenges and other biomanufacturing considerations		rofessor DeLisa		
F	2-Apr	21	Guest Lecture - Erin Johnson (MERK) Up Stream Processing		Erin Johnson		
F	9-Apr	22	WPR II		Dr. Yuk	WPR 2	200/740
			Block III: Downstream Considerations				
Tu	13-Apr	23	Product recovery and separation - Part 1	Ch 11.1-11.3 (Schuler et al)	Dr. Yuk		
Th	15-Apr	24	Product recovery and separation Part 2	Ch 11.4-11.7 (Schuler et al)	Dr. Yuk		
M	19-Apr	25	Bio Process Considerations using Animal Cells	Ch 12 (Schuler et al)	Dr. Yuk	Discussion Grade 4	30/770
Th	22-Apr	26	Bio Process Considerations using Plant Cells	Ch 13 (Schuler et al)	Dr. Yuk		
M	26-Apr	27	Medical Applications of Bioprocess Engineering	Ch 15 (Schuler et al)	Dr. Yuk		
F	30-Apr	28	Traditional Industrial Bioprocesses	Appendix A (Schuler et al)	Dr. Yuk	Discussion Grade 5	30/800
Tu	4-May	29	Capstone Presentations		Dr. Yuk	Capstone Paper	200/1000
M	10-May	30	Cadet Presentations		Dr. Yuk	Capstone Presentation	100/1100
			TEE Week of 12-15 DEC 2021			TOTAL POINTS	1100

PS's	250
WPR's	400
DG's	150
Paper	200
Pres	100
TOTAL	1100

CH350 Conditions Check

Requirement	GO/NOGO	ETA	Notes
Test Course Memo	GO		
3.0 ET Memo	NOGO	???	Waiting on graded events
Permanent Course Memo	NOGO		
Syllabus	GO		
SIS	GO		
Lesson Assignment Sheets	GO		
PS’s	NOGO	21-Apr	In Progress
WPRs	NOGO	21-Apr	In Progress
Capstone	GO		
TEXTBOOK Locked in on MBS	GO		
Course Enrollment	GO		14 in AY22-1; 9 in AY23-1
FDW Scheduled	GO		

CH300 Course Overview

CH300 Integrated Sequence COA

COA 1

Block I: Molecular and cellular principles
- Biomolecular principles (Ch. 2)
- Biomolecular principles: Nucleic acids (Ch. 3)
- Biomolecular principles: proteins (Ch. 4)
- Cellular principles (Ch. 5)

Block II: Physiological principles
- Communication systems in the body (Ch. 6)
- Engineering balances: respiration and digestion (Ch. 7)
- Circulation (Ch. 8)
- Removal of molecules from the body (Ch. 9)

CH300 Solitary Course COA

COA 2

Block I: Molecular and cellular principles
- Biomolecular principles (Ch. 2)
- Biomolecular principles: Nucleic acids (Ch. 3)
- Biomolecular principles: proteins (Ch. 4)
- Cellular principles (Ch. 5)

Block II: Physiological principles
- Communication systems in the body (Ch. 6)
- Engineering balances: respiration and digestion (Ch. 7)
- Circulation (Ch. 8)
- Removal of molecules from the body (Ch. 9)

Block III: Biomedical Engineering
- Biomechanics (Ch. 10)
- Bioinstrumentation (Ch. 11)
- Bioimaging (Ch. 12)
- Biomolecular Engineering I: Biotechnology (Ch. 13)
- Biomolecular Engineering II: Engineering of Immunity (Ch. 14)

Requirement	GO/NOGO	ETA	Notes
Test Course Memo	GO		
3.0 ET Memo	NOGO		Waiting on graded events
Syllabus	NOGO		Need Dept Head Approval
SIS	NOGO	1MAY	MAJ Corrigan
Lesson Assignment Sheets	NOGO		
PS's	NOGO		
WPRs	NOGO		
Capstone	NOGO	1MAY	MAJ Corrigan
Textbook Adoption	NOGO		Need Dept Head Approval
Publisher Solutions to End of Ch Probs	NOGO		MAJ Chin working
Course Enrollment	NOGO		2 in AY22-1; 11 in AY23-1

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CH300 Syllabus – COA 1

CH300 - Biomedical Engineering (AY 22-2)

2-Days during ##-hr (####-####) in BH630 Text: Biomedical Engineering, 2nd Edition, W. Mark Saltzman

Day	2-Day	LSN	Subject	Reading	Instructor	Event	(T) Possible Event	Points
			Part I: Molecular and Cellular Properties					
		1	What is Biomedical Engineering	Scan Chapter 1	COL Burpo			
		2	Biomolecular principles	Chapter 2: 2.1 -2.3	COL Burpo			
		3	Biomolecular principles	Chapter 2: 2.4 -2.5	COL Burpo			
		4	Biomolecular principles	Chapter 2: 2.6 -2.7	COL Burpo	Problem Set 1 Due		50/50
		5	Biomolecular principles: Nucleic acids	Chapter 3: 3.1-3.3	COL Burpo			
		6	Biomolecular principles: Nucleic acids	Chapter 3: 3.1-3.3	COL Burpo			
		7	Biomolecular principles: Nucleic acids	Chapter 3: 3.1-3.3	COL Burpo	Problem Set 2 Due		50/100
		8	Biomolecular principles: Proteins	Chapter 4: 4.1-4.2	COL Burpo			
		9	Biomolecular principles: Proteins	Chapter 4: 4.3-4.4	COL Burpo			
		10	Cellular principles	Chapter 5: 5.1-5.4	COL Burpo			
		11	Cellular principles	Chapter 5: 5.4-5.5	COL Burpo	Problem Set 3 Due		50/150
		12	Cellular principles	Chapter 5: 5.6-5.8	COL Burpo			
		13	Guest Research Lecture	Article	TBD			
		14	WPR I		COL Burpo	WPR I		200/350
			Part II: Physiological Principles					
		15	Guest Research Lecture	Article	TBD			
		16	Communication systems in the body	Chapter 6: 6.1-6.2	COL Burpo			
		17	Communication systems in the body	Chapter 6: 6.3-6.4	COL Burpo		Term Project IPR	
		18	Communication systems in the body	Chapter 6: 6.5-6.6	COL Burpo			
		19	Engineering balances: respiration and digestion	Chapter 7: 7.1-7.2	COL Burpo	Problem Set 4 Due		50/400
		20	Engineering balances: respiration and digestion	Chapter 7: 7.3	COL Burpo			
		21	Engineering balances: respiration and digestion	Chapter 7: 7.4				
		22	Circulation	Chapter 8: 8.1-8.2 + Article	COL Burpo			
		23	Circulation	Chapter 8: 8.3	COL Burpo			
		24	Circulation	Chapter 8: 8.4	COL Burpo	Problem Set 5 Due		50/450
		25	Removal of molecules from the body	Chapter 9: 9.1-9.3	COL Burpo			
		26	Removal of molecules from the body Kidneys P1	Chapter 9: 9.1-9.4	COL Burpo			
		27	Removal of molecules from the body Kidneys P2	Chapter 9: 9.1-9.4	COL Burpo	Problem Set 6 Due		50/500
		28	WPR III			WPR II		200/700
		29	Capstone Presentations		COL Burpo		Presentations	200/900
		30	Capstone Presentations		COL Burpo		Presentations	
							TOTAL POINTS	900

UNITED STATES MILITARY ACADEMY
WEST POINT.

CH300 Syllabus – COA 2

CH300 - Biomedical Engineering (AY 22-2)

2-Days during ##-hr (####-####) in BH630   Text: Biomedical Engineering, 2nd Edition, W. Mark Saltzman

Day	2-Day	LSN	Subject	Reading	Instructor	Event	(T) Possible Event	Points
			Part I: Molecular and Cellular Properties					
		1	Biomolecular principles	Chapter 2: 2.1-2.5	COL Burpo			
		2	Biomolecular principles	Chapter 2: 2.6-2.7	COL Burpo			
		3	Biomolecular principles: Nucleic acids	Chapter 3: 3.1-3.3	COL Burpo			
		4	Biomolecular principles: Nucleic acids	Chapter 3: 3.4-3.7	COL Burpo	Problem Set 1 Due		50/50
		5	Biomolecular principles: Proteins	Chapter 4: 4.1-4.4	COL Burpo			
		6	Cellular principles	Chapter 5: 5.1-5.4	COL Burpo			
		7	Cellular principles	Chapter 5: 5.5-5.8	COL Burpo			
		8	WPR I		COL Burpo	WPR I		200/250
			Part II: Physiological Principles					
		9	Communication systems in the body	Chapter 6: 6.1-6.3	COL Burpo			
		10	Communication systems in the body	Chapter 6: 6.4-6.6	COL Burpo			
		11	Engineering balances: respiration and digestion	Chapter 7: 7.1-7.2	COL Burpo			
		12	Engineering balances: respiration and digestion	Chapter 7: 7.3-7.4	COL Burpo	Problem Set 2 Due		50/300
		13	Circulation	Chapter 8: 8.1-8.3	COL Burpo			
		14	Circulation	Chapter 8: 8.4	COL Burpo			
		15	Removal of molecules from the body	Chapter 9: 9.1- 9.3	COL Burpo	Problem Set 3 Due		50/350
		16	Removal of molecules from the body	Chapter 9: 9.4	COL Burpo			
		17	Guest Research Presentation		TBD			
			Part III: Biomedical Engineering					
		18	Biomechanics	Chapter 10: 10.1-10.2	COL Burpo			
		19	Biomechanics	Chapter 10: 10.3-10.4	COL Burpo		Capstone IPR	
		20	Bioinstrumentation	Chapter 11: 11.1-11.3	COL Burpo	Problem Set 4 Due		50/400
		21	Bioinstrumentation	Chapter 11: 11.4-11.7	COL Burpo			
		22	Bioimaging	Chapter 12: 12.1-12.3	COL Burpo			
		23	Bioimaging	Chapter 12: 12.4-12.7	COL Burpo	Problem Set 5 Due		50/450
		24	Biomolecular Engineering I: Biotechnology	Chapter 13: 13.1-13.2	COL Burpo			
		25	Biomolecular Engineering I: Biotechnology	Chapter 13: 13.3-13.5	COL Burpo			
		26	WPR II			WPR II		200/650
		27	Biomolecular Engineering II: Engineering of Immunity	Chapter 14: 14.1-14.4	COL Burpo			
		28	Biomolecular Engineering II: Engineering of Immunity	Chapter 14: 14.5-14.6	COL Burpo	Problem Set 6 Due		50/700
		29	Capstone Presentations				Presentations	200/900
		30	Capstone Presentations				Presentations	
							TOTAL POINTS	900

CH450 Detailed Overview – Syllabus

UNITED STATES MILITARY ACADEMY
WEST POINT.

Facts/Assumptions

- Historically CH450 taken by majority LS majors
- Assume new enrollment will shift to majority Chem E (based off enrollment in CH350/CH300)
- Increased need for overview of basic biological concepts

Recommendation

- COA 1 for CH300
- Possible name change to Introduction to BME?
- Alternatively, add some application lessons to COA 1.

CH450 - Bioengineering Modeling, Analysis, & Design (AY 21-2)

2-Days during I2-hr (1045-1155) in BH630 Text: Biomedical Engineering, 3rd Ed., Enderle & Bronzino

Day	2-Day	LSN	Subject	Reading	Instructor	Event	Points
			Part I: Biomechanics				
Th	21-Jan	1	Intro & Modeling	Scan Chapter 1; weblinks	COL Burpo	Modeling Exercise	
M	25-Jan	2	Biomechanics I	4.1-4.3	COL Burpo		
Th	28-Jan	3	Biomechanics II	4.4-4.5	COL Burpo	Quiz 1	
M	1-Feb	4	Biomechanics III	4.6, Article	COL Burpo	Quiz 1 Turn-in	30/30
F	5-Feb	5	Paper Discussion: Biomechanics	Article	COL Burpo	Discussion Grade 1	30/60
			Part II: Biomaterials				
Tu	9-Feb	6	Biomaterials I	5.1-5.3	COL Burpo	Problem Set 1 Due	100/160
Th	11-Feb	7	Biomaterials II	5.4-5.7	COL Burpo	Quiz 2	30/190
			Presidents Day Weekend (13-15 Feb 21)				
Tu	16-Feb	8	Biomaterials III	Viscoelasticity, Roylance	COL Burpo		
Th	18-Feb	9	Modeling: Biomaterials	Viscoelasticity, Roylance	COL Burpo		
M	22-Feb	10	Paper Discussion: Biomaterials	Article	COL Burpo	Discussion Grade 2	30/220
			Part III: Tissue Engineering				
F	26-Feb	11	Tissue Engineering I	6.1-6.2	COL Burpo	Problem Set 2 Due	100/320
Tu	2-Mar	12	Tissue Engineering II	6.3	COL Burpo	Quiz 3	30/350
Th	4-Mar	13	Tissue Engineering III	6.4-6.7	COL Burpo		
			"Spring Break" (6-8 Mar 21)				
Tu	9-Mar	14	Modeling: Tissue Engineering	Handout	COL Burpo		
F	12-Mar	15	Paper Discussion: Tissue Engineering	Article	COL Burpo	Discussion Grade 3	30/380
			Part IV: Biochemical Enzyme Kinetics (Biocatalysis)				
Tu	16-Mar	16	Compartment Modeling	7.1-7.5	Dr. Yuk	Problem Set 3 Due	100/480
Th	18-Mar	17	Biochemical Enzyme Kinetics I	8.1-8.2	COL Burpo		
M	22-Mar	18	Biochemical Enzyme Kinetics II	8.3	COL Burpo	Quiz 4	30/510
F	26-Mar	19	Modeling - Biochemical Enzyme Kinetics	Handout	COL Burpo	Term Project IPR	(50)
W	31-Mar	20	Paper Discussion: Enzyme Kinetics		COL Burpo	Discussion Grade 4	30/540
			Part V: Biochemical Engineering				
F	2-Apr	21	Biochemical Engineering I	Handout	MAJ Corrigan		100/640
			"Spring Break Part 2" (3-5 Apr 21)				
F	9-Apr	22	Biochemical Engineering II	Handout	COL Burpo	Problem Set 4 Due	
Tu	13-Apr	23	Biochemical Engineering III	Handout	Dr. Nagelli		30/670
Th	15-Apr	24	Modeling: Biochemical Engineering	Handout	COL Burpo	Quiz 5	
M	19-Apr	25	Paper Discussion: Biochemical Engineering	Article	COL Burpo	Discussion Grade 5	30/700
			Part VI: Biosensors				
Th	22-Apr	26	Biosensors I	12.1-12.5	COL Burpo	Problem Set 5 Due	100/800
M	26-Apr	27	Biosensors II	10.1-10.2	COL Burpo	Quiz 6	30/830
F	30-Apr	28	Modeling: Biosensors	Handout	COL Burpo		
Tu	4-May	29	Paper Discussion: Biosensors	Article	COL Burpo	Discussion Grade 6	30/860
Th	7-May					Submit Term Project	150/1010
M	10-May	30	Cadet Presentations				50/1060
			TEE Week of 12-15 May 2021			TOTAL POINTS	1060

CH300: Introduction to Biomedical Engineering

Course Director: COL Burpo

Course OIC: MAJ Jeffrey Chin

Credit Hours: 3.0 (BS=0, ET=3.0, 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.

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%

TEXT: Biomedical Engineering, 2nd Edition, by W. Mark Saltzman; Cambridge University Press, 2015.

COA 1

Block I: Molecular and cellular principles
- Biomolecular principles (Ch. 2)
- Biomolecular principles: Nucleic acids (Ch. 3)
- Biomolecular principles: proteins (Ch. 4)
- Cellular principles (Ch. 5)

Block II: Physiological principles
- Communication systems in the body (Ch. 6)
- Engineering balances: respiration and digestion (Ch. 7)
- Circulation (Ch. 8)
- Removal of molecules from the body (Ch. 9)

COA 2

Block I: Molecular and cellular principles
- Biomolecular principles (Ch. 2)
- Biomolecular principles: Nucleic acids (Ch. 3)
- Biomolecular principles: proteins (Ch. 4)
- Cellular principles (Ch. 5)

Block II: Physiological principles
- Communication systems in the body (Ch. 6)
- Engineering balances: respiration and digestion (Ch. 7)
- Circulation (Ch. 8)
- Removal of molecules from the body (Ch. 9)

Block III: Biomedical Engineering
- Biomechanics (Ch. 10)
- Bioinstrumentation (Ch. 11)
- Bioimaging (Ch. 12)
- Biomolecular Engineering I: Biotechnology (Ch. 13)
- Biomolecular Engineering II: Engineering of Immunity (Ch. 14)

CH350: Introduction to Bioengineering

Course Director: Dr. Simuck Yuk

Credit Hours: 3.0 (BS=0, ET=3.0, MA=0)
Prerequisites:
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

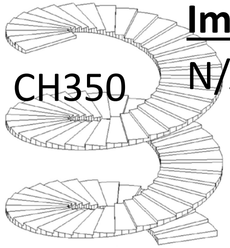
Bioprocess Engineering Basic Concepts, 3rd Ed., by Michael L. Shulter, Fikret Kargi, Matthew DeLisa, Prentice Hall.

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:
N/A at this point.



CH350

Improve:
N/A at this point.

Assessment – Graded Events

1 *Capstone Presentation	200	14%
2 *WPRs	400	28%
5 *After-class Problem Sets(20pts/ea.)	100	7%
5 *In-class Problem Sets (50pts/ea.)	250	17%
1 *Term End Exam	500	34%
Total:	1450	100.00%

CH450: Bioengineering Modeling and Analysis

Course Director: COL John Burpo

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

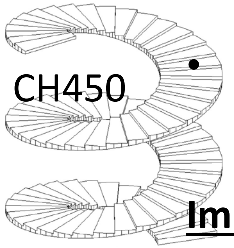
This course provides a broad understanding of bioengineering disciplines to include biomechanics, biomaterials, tissue engineering, biocatalysis, biochemical engineering, and biosensors. Fundamental concepts of molecular kinetics, thermodynamics, and mass transport are applied in problem sets in each bioengineering sub-discipline and capstone design project providing students the opportunity for modeling, analysis, and design from the biomolecular to physiological length scale and across multiple time scales. Modeling software such as MATLAB and Mathematica is extensively used.

Topics – by Chapter

TEXT: Introduction to Biomedical Engineering, 3rd Edition, by John Enderle and Joseph Bronzino; Academic Press, 2012.

- Part I: Biomechanics (Ch. 1 and 4)
- Part II: Biomaterials (Ch. 5)
- Part III: Tissue Engineering (Ch. 6)
- Part IV: Biomedical Enzyme Kinetics (Ch. 7 and 8)
- Part V: Biochemical Engineering (Handouts)
- Part VI: Biosensors (Ch. 10)

Course Assessment – Items from Section III



Sustain:

- Best looking Dept Head/ CD/ Prof at the academy
- Strong instructor personal experience in mathematics, engineering, and chemistry
- Each lesson considers interdisciplinary science and engineering topics –science topics are taught in context of engineering applications

Improve:

Assessment – Graded Events

5 *Problem Sets@ 25 pts each	500	47.2%
6 *Quizes @ 200 pts each:	180	17.0%
1 *Paper	150	14.1%
1 *Presentation	50	4.7%
6 *Discussion	180	17.0%
Total:	1060	
*Individual Points :	1060	100%

ABET VISIT (AY21)		AY22		AY23	
AY21-1 (Fall)	AY21-2 (Spring)	AY22-1 (Fall)	AY22-2 (Spring)	AY23-1 (Fall)	AY23-2 (Spring)
CH363 (Armstrong)	CH362 (Corrigan)	CH363 (Armstrong)	CH362 (Cowart)	CH363 (Belanger)	CH362 (Cowart)
CH459 (Nagelli)	CH364 (Cowart)	CH459 (Nagelli)	CH364 (Yuk)	CH459 (Nagelli)	CH364 (Yuk)
CH485 (Cowart)	CH402 (Nagelli)	CH485 (Cowart)	CH402 (Biaglow)	CH485 (Cowart)	CH402 (Biaglow)
CH365 (Biaglow)	CH400 (Armstrong)	CH365 (Biaglow)	CH400 (Nagelli)	CH365 (Biaglow)	CH400 (Nagelli)
	CH367 (James)	CH350(Yuk)	CH367 (James)	CH350(Yuk)	CH367 (James)
	CH450 (Burpo)		CH450 (Burpo)		CH450 (Burpo)
			CH300(Burpo)		CH300(Burpo)
Yuk (CG - 3x sections)	Yuk (CG - 3x sections)	Yi (2x GC sections)	Mandes (3x GC sections)	Lowell, Sam(3x GC)	Lowell, Sam(3x GC)
Chin (GC - 3x sections)	Chin (GC - 3x sections)	Bowers (GC 3x sections)	Bowers (GC 3x sections)	Mandes (GC)	Mandes (GC)
Corrigan (2x sections + S4)	Armstrong (2x GC sections)	Mandes (GC 3x sections)	Yi (2x GC sections)	Yi (GC)	Belanger (GC)
Yi (GC - 3x sections)	Yi (GC - 3x sections)	Chin (2x sections+S1)	Chin (2x sections+S1)	Chin (GC+S1)	Chin (GC+S1)
	Biaglow (Sabbatical)			Bowers (GC)	Bowers (GC)
				Belanger (2x GC sections)	Yi (2x GC sections)

AY24		AY25		AY26	
AY24-1 (Fall)	AY24-2 (Spring)	AY25-1 (Fall)	AY25-2 (Spring)	AY25-1 (Fall)	AY25-2 (Spring)
CH363 (Belanger)	CH362 (Cowart)	CH363 (Nagelli)	CH362 (Cowart)	CH363 (Nagelli)	CH362 (Cowart)
CH459 (Nagelli)	CH364 (Yuk)	CH459 (Belanger)	CH364 (Yuk)	CH459 (Belanger)	CH364 (Yuk)
CH485 (Cowart)	CH402 (Biaglow)	CH485 (Cowart)	CH402 (Biaglow)		CH402 (Biaglow)
CH365 (Biaglow)	CH400 (Nagelli)	CH365 (Biaglow)	CH400 (Nagelli)	CH365 (Biaglow)	CH400 (Nagelli)
CH350(Yuk)	CH367 (James)	CH350(Yuk)	CH367 (James)	CH350(Yuk)	CH367 (James)
	CH450 (Burpo)		CH450 (Burpo)		CH450 (Burpo)
	CH300(Belanger)		CH300(Belanger)		CH300(__)
Mandes (GC)	Mandes (GC)	Rogers (GC)	Rogers (GC)	Rogers (GC)	Rogers (GC)
Bowers (GC)	Bowers (GC)	Golonksi(GC)	Golonksi(GC)	Golonksi(GC)	Golonksi(GC)
Rogers (GC)	Rogers (GC)	Tobergte(GC)	Tobergte(GC)	Tobergte(GC)	Tobergte(GC)
	Lowell, Sam(3x GC)				
	Belanger (GC)				

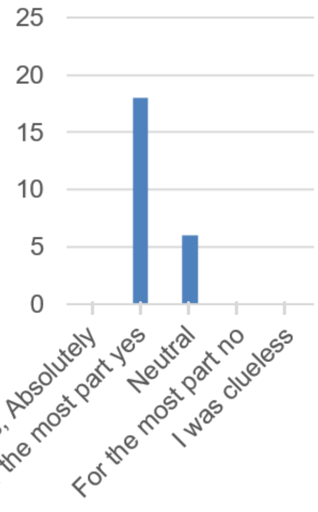
As of 15APR Class of 2021: 75% passing FEE first time

National, (+/- ~1%):

2020	74.6%
2019	77.0%
2018	75.0%
2017	74.0%
2016	79.0%
2015	77.4%

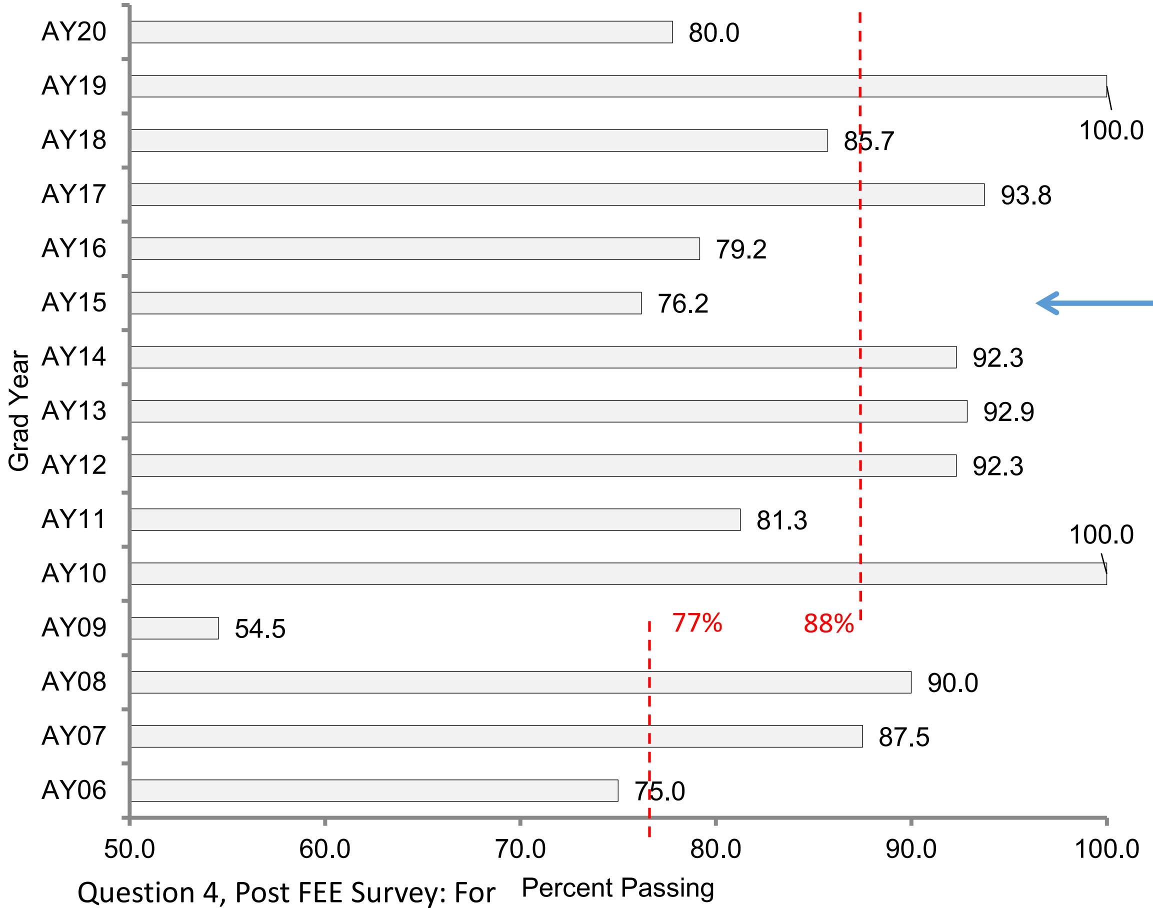
2014	89.0%
2013	86.3%
2012	85.1%
2011	87.0%
2010	87.0%
2009	84.0%
2008	87.0%
2007	87.0%
2006	87.0%

Question 4



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

Percent of cadets passing the FE Exam



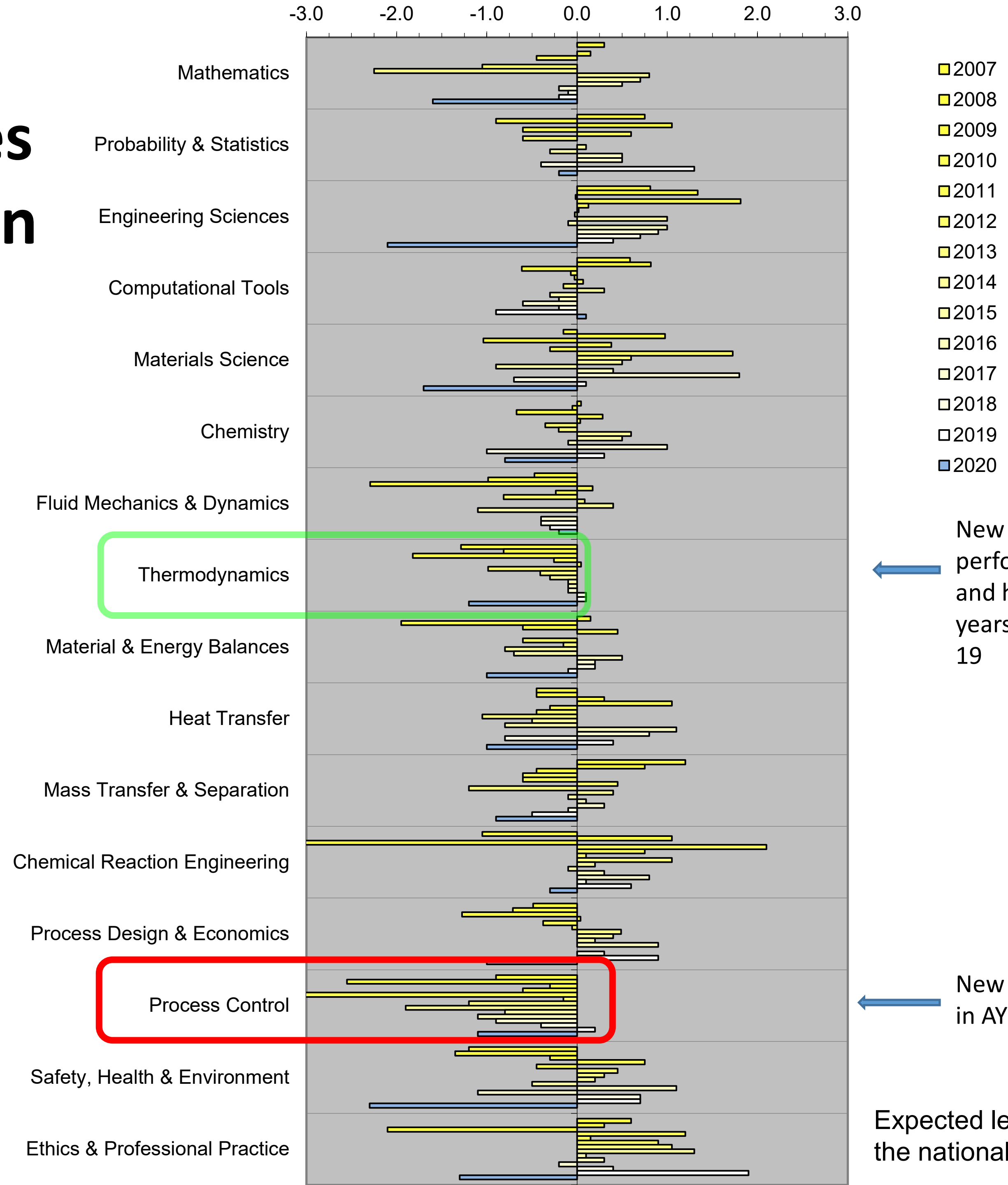
Electronic Testing Initiated

CH400 Initiated

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 AY07 to AY20



New course added in AY13. Trend in performance continues in the right direction and has now been positive two successive years, with a setback in AY20 due to COVID-19

New course added in AY16 and implemented in AY19-2

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

ABET Advisory Board(23APR21remote?)

- Combination of representatives from our constituencies:
  - Industry
  - Academia
  - Army
- Review data; take survey; interact with Chemical Engineering Cows and Firsties
- Give curriculum advice
- Inform program decisions
- Helps write the program educational objectives and mission statement (these are ABET requirements)

No.	Name	Title	School - Company	Email
1	Kevin Shipe	Automation Engineer	NALCO Champion	kevin.a.shipe@gmail.com
2	Lucy Hair	EleCent Team Leader	LLNL	hair1@llnl.gov
3	COL (Ret) Paul Dietrich	Chemical Officer	Chemical Officer/Industry	paul@the-dietrichs.com
4	Kisondra Waters	Principal Analyst	Margin Analytics	kisondra@gmail.com
5	Anthony Hatfield	Consultant Engineer	Eli Lilly and Company	hatfield@lilly.com
6	Donald Glaser	President	Simulation Solutions	dglaser@simulation-solutions.com
7	Matt Garvey		Simulation Solutions	mgarvey@simulation-solutions.com
8	Kelly Schutz	Assistant Professor	Lehigh University	kes513@lehigh.edu
9	Lynn Walker	Professor	Carnegie Mellon University	lwalker@anderw.cmu.edu
10	Matthew Libertore	Professor	University of Toledo	matthew.liberatore@Utoledo.edu
11	Patrick Nonhof	Managing Partner	Provenance Consulting	Patrick.Nonhof@provenanceconsulting.com
12	Dwight Springer	COL(RET)	Retired Deputy Head	dss5456@verizon.net
13	Greg Ritch	COL(RET)/ Engineering Officer	MIL/Industry	garitch@cvzoom.net
14	Mike Deforest	Industry, Chem E (Old Grad '07)	SMK Packaging	mike@smkpackaging.com
15	Phil Visser	Chem Corps; COL (RET)		cell: 7572543017
16	Patrick Underhill	Associate Professor	RPI	underhill@rpi.edu
17	Rich, Greg	COL(RET)		garitch@cvzoom.net
	Alternating			
	Go			
	No go for this year			
	Maybe			

Questions

Backup Slides

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.

ABET

Engineering Technology Accreditation Commission

Accredited 1 October 2012 to present

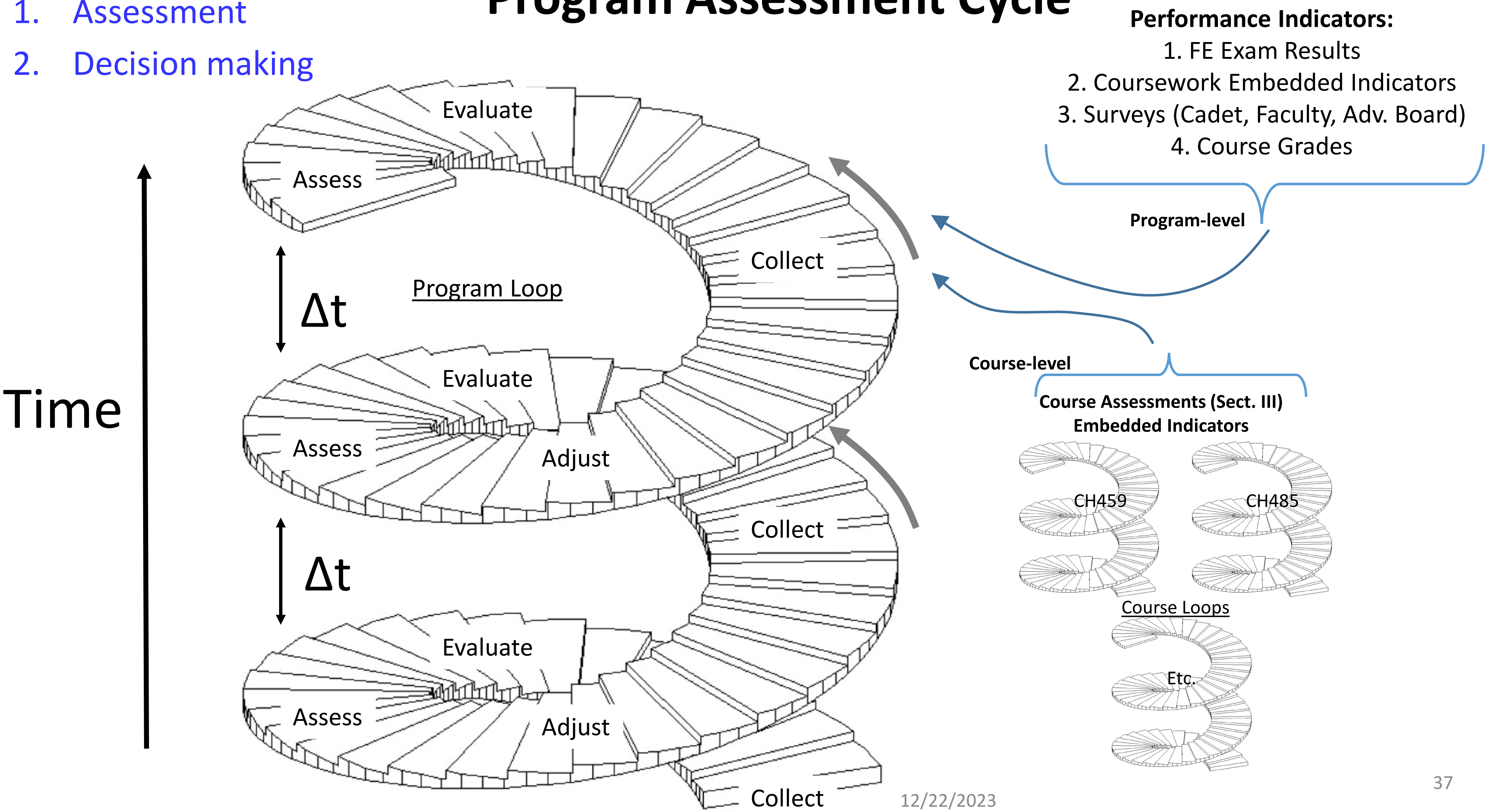
Next Record Year: AY20

Next ABET Visit: Fall 2020 (AY21-1)

Data used to support:

1. Assessment
2. Decision making

Program Assessment Cycle



*Student Outcomes

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.

Performance Indicators

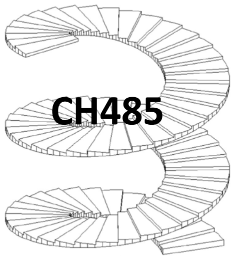
- Coursework embedded indicators (example to be shown)
- Cadet end-of-semester surveys
- FE Exam results
- Cadet grades in program courses
- Advisory Board student outcome surveys
- Faculty student outcome surveys

Course Assessment Cycle

Table 4-1. Outline of the course assessment process

- Published guidance in CD Handbook
- Required for all chemical engineering courses used for assessment (not optional)
- Similar system for courses outside department

Description	Assessment	Recommendations
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 - Recommendations 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.		



- Sustain and improve from last AY

Example Schedule for Chemical Engineering Classes of 20xx and Beyond

Fall Term	Course	Credit Hours	Spring Term	Course	Credit Hours
4th CLASS					
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
HI107	Western Civilization	3.0	HI108	Regional Studies in World History	3.0
IT105	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*	*Applied Engineering Math*	*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 1*	*3.5*	*MC312*	*Thermal-Fluid Systems 2*	*3.0*
MC311	*Thermal-Fluid Systems 1*	*3.5*	*Elective*	*Engineering Elective 1*	*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	18.5
CH459	*Chemical Engineering Laboratory*	*3.5*	*CH402*	*Chemical Engineering Process Design 2*	*3.5*
CH365	*Chemical Engineering Thermodynamics*	*3.0*	*CH400*	*Chemical Engineering Prof. Practice*	*3.0*
CH485	*Heat & Mass Transfer*	*3.5*	*Elective*	*Engineering Elective 3*	*3.0*
CH401	*Chemical Engineering Process Design 1*	*3.5*	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
	Total	18.0		Total	18.5

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
MC311	Thermal-Fluid Systems I
MC312	Thermal-Fluid Systems II
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 Student Outcomes

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

Chemical Engineering Program Objectives

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

- 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.
- Demonstrate effective leadership and chemical engineering expertise.

Chemical Engineering Program Population