

**Spring 2022 CHEN 2120**  
**Chemical Engineering Material and Energy Balance**

**Instructor:** **Prof. Anushree Chatterjee**  
BIOT D123  
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Phone: 303-735-6586

**Advanced Teaching:** **Paula Pranda**  
**Assistant (TA):** E-mail address: [Paula.Pranda@colorado.edu](mailto:Paula.Pranda@colorado.edu)

**Class Meeting Times/Dates:**

Mon, Wed, and Fri: 12:50 PM- 1:40 PM BIOT A104

**Pre-requisites:** GEEN 1300 Introduction to Engineering Computing (grade of C- or better). CHEM 1211 General Chemistry for Engineers (grade of C- or better)

**Text:** Felder/ Elementary Principles of Chemical Processes, 4th Edition or higher

978-1-119-19023-3 ebook

978-1-118-43122-1 Print

A low-cost option is purchasing the electronic text for the course. A direct purchase link to e-book has been created by wiley.com for you:

<https://www.wiley.com/en-us/Elementary+Principles+of+Chemical+Processes%2C+4th+Edition-p-9781119192107>

**Course website and Communication:**

Canvas (<https://canvas.colorado.edu/courses/80823>) will be used for class information, lecture notes, class problems, reading quizzes, grades, online recitations, exam information, and office hours. You will also be able to access screencasts from there. Communication about Homeworks and Quizzes should be directed to Paula (your TA). Any personal communication should be sent directly to Prof. Chatterjee.

**Zoom link for the class:** Zoom link will be used for all remote lectures and office hours. Office hours may be held in hybrid version depending on the instructions from the University.

**Join Zoom Meeting**

<https://cuboulder.zoom.us/j/98018416583>

Meeting ID: 980 1841 6583

Passcode: MEB2022

One tap mobile

+13462487799,,98018416583# US (Houston)

+16699006833,,98018416583# US (San Jose)

Dial by your location

+1 346 248 7799 US (Houston)

+1 669 900 6833 US (San Jose)

+1 253 215 8782 US (Tacoma)

+1 312 626 6799 US (Chicago)

+1 646 558 8656 US (New York)

+1 301 715 8592 US (Washington DC)

Meeting ID: 980 1841 6583

Find your local number: <https://cuboulder.zoom.us/u/adIaKDVaOd>

Join by SIP  
[98018416583@zoomcrc.com](mailto:98018416583@zoomcrc.com)

Join by H.323  
162.255.37.11 (US West)  
162.255.36.11 (US East)  
115.114.131.7 (India Mumbai)  
115.114.115.7 (India Hyderabad)  
213.19.144.110 (Amsterdam Netherlands)  
213.244.140.110 (Germany)  
103.122.166.55 (Australia Sydney)  
103.122.167.55 (Australia Melbourne)  
149.137.40.110 (Singapore)  
64.211.144.160 (Brazil)  
149.137.68.253 (Mexico)  
69.174.57.160 (Canada Toronto)  
65.39.152.160 (Canada Vancouver)  
207.226.132.110 (Japan Tokyo)  
149.137.24.110 (Japan Osaka)  
Meeting ID: 980 1841 6583  
Passcode: 8864308

#### **Recitations and Office Hours:**

Day	Person	Time	Room
Monday	Anushree	1:45 PM – 2:45 PM	Zoom link provided or BIOT A104
Tuesday	Paula	5 PM - 6 PM	Zoom link provided or BIOT E125
Wednesday	Anushree	1:45 PM – 2:45 PM	Zoom link provided or BIOT A104
Thursday	Paula	5 PM - 6 PM	Zoom link provided or BIOT E125

#### **Pre-class Quizzes due (starting Jan 15<sup>th</sup>, 2022):**

Day quiz due	When Open?	When closed/due?	Details
Mon, Wed and Fri	End of previous class	12:30 PM (before class)	60 min allowed-max two attempts

#### **Home works due ONCE a week on Fridays:**

Day	When Due?	When Due?
Friday	Every week	11:59 PM

## Instructions for how to register on Homework portal called Achieve?

[Achieve > Students: Register for Achieve Courses via your School's LMS \(force.com\)](#)

**Course Content:** The course, "Material and Energy Balances", is *the flagship* course in chemical engineering. Because it provides a base for all later chemical engineering courses (transport processes, thermodynamics, reaction kinetics, unit operations, design, etc.), an understanding of the material is critical for future success. The content of the course is fairly standard: definitions, measurement, and estimation of various process variables and physical properties of process materials (mass, volume, pressure, temperature, energy); descriptions and *flow charts of unit operations* and integrated processes; gas laws and phase equilibrium relations; **laws of conservation of mass and energy**, and the incorporation of all of the above into material and energy balance calculations on individual chemical process units and multi-unit processes. The material is not intrinsically difficult, but the approach required to set up and solve course problems takes most students considerable time to grasp.

The principal concepts that all students must bring with them from their prior education come from mathematics (basic algebra and graphical manipulations, solving sets of linear equations, word problems, and calculus), physics (phases of matter, conservation of mass), and chemistry (atoms and molecules, stoichiometric equations, molecular weight, and molar quantities). Students will need to be able to carry out spreadsheet type calculations using Excel™, be able to write simple VBA programs and have a basic understanding of general chemistry. No instruction will be given on the general use of Excel. The reason for using spreadsheet calculations extensively is that spreadsheets are widely available to practicing engineers, while Matlab and Mathematica are generally not.

### **Class Format:**

This class will be taught as a “flipped classroom”. In other words, lecturing will be done outside class through screencasts and reading, while the classroom time will be spent on conceptual questions and problem solving. In order for you to benefit from this approach:

- Reading assignments and screencasts will be assigned for every class. The class will be conducted with the assumption that you have read/watched them.
- There will be reading quizzes due on M, W and F and homework problems due Friday. These will be due by 12:30 pm before class. Quizzes will be opened after the previous lecture.**
- Class problems for each class will be posted on-line. Please look through these before class so you are prepared to follow the pace. I will assume that you have done so and have a copy of these problems and will use my class time accordingly.
- Bring your book to class every day. You will need the conversions as well as tables. Also, bring your calculator.

**Problem Solving Method Building:** Engineering is an applied field in which success requires problem solving skills, knowledge of current sources of information, and an understanding of how to use readily available tools. Because of these aspects:

- the amount of knowledge gained from assigned homework will be significant – make sure you completely understand the problems and concepts from both class and homework. Do not rely on your classmates for assignments – you will be the one taking the exam.
- required screencasts and reading quizzes will supplement the assigned homework.
- in-class concept tests will count in your grade and help you with the "why" aspect of the class.

### **Policies and Procedures:**

**Disability statement.** If you qualify for accommodations because of a disability, please submit to your professor a letter from Disability Services in a timely manner (for exam accommodations provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at [dsinfo@colorado.edu](mailto:dsinfo@colorado.edu). If you have a temporary medical condition or injury, see Temporary Medical Conditions: Injuries, Surgeries, and Illnesses guidelines under Quick Links at Disability Services website and discuss your needs with your professor.

**Honor Code and Academic Dishonesty.** All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include:

cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council ([honor@colorado.edu](mailto:honor@colorado.edu); 303-735-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at <http://www.colorado.edu/policies/honor.html> and at <http://honorcode.colorado.edu>. Additionally, the course instructor will report the incident to the Academic Ethics Committee of the Department of Chemical and Biological Engineering. This Committee will recommend to the instructor whether a sanction should be applied to the student. Typical sanctions may range from a zero on an assignment in question to an F in the course. Whether or not the student has admitted the act, in light of the preponderance of the evidence, may factor into the recommendation of the Committee.

**Disabilities:** If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs may be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and <http://www.Colorado.EDU/disabilityservices>.

**Religious Observances.** Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, the student must notify the professor at the beginning of the semester of any conflicts with regard to the examination times. For homework assignments and missed clicker questions, the student must notify the professor at least 2 weeks in advance to make special arrangements. See full details at [http://www.colorado.edu/policies/fac\\_relig.html](http://www.colorado.edu/policies/fac_relig.html).

**Behavioral standards.** Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, color, culture, religion, creed, politics, veteran's status, sexual orientation, gender, gender identity and gender expression, age, disability, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See policies at <http://www.colorado.edu/policies/classbehavior.html> and at [http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student\\_code](http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code).

**Discrimination and Sexual Harassment.** The University of Colorado Boulder (CU-Boulder) is committed to maintaining a positive learning, working, and living environment. CU-Boulder will not tolerate acts of discrimination or harassment based upon Protected Classes or related retaliation against or by any employee or student. For purposes of this CU-Boulder policy, "Protected Classes" refers to race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Individuals who believe they have been discriminated against should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Student Conduct (OSC) at 303-492-5550. Information about the ODH, the above referenced policies, and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at <http://hr.colorado.edu/dh/>

## **CEAS Values Statement**

### **Preamble:**

The College of Engineering and Applied Science at the University of Colorado Boulder—like other higher education institutions in the United States—is in the midst of a mental health crisis with respect to its more recent entering student cohorts. These students are part of Generation Z and this generation is significantly more likely to arrive at college having had treatment for mental health challenges. Approximately 27% of Gen Z members characterize their mental health as fair to poor, a higher reported number than any cohort in American history (APA.org, 2018). These trends are felt here at CU; indeed Student Affairs reports an increased incidence rate of mental health concerns within the Gen Z cohort at CU. These statistics were made real for CEAS during the 2018-2019 academic year and subsequent summer when we experienced the loss of eight CEAS majors to suicide.

Given this significant spike in the suicide rate, the Dean as well as multiple faculty and staff felt that the college must focus its efforts on the health and wellness of our students, faculty, and staff. To that end, a committee was formed at the end of the Spring 2019 semester to work over the summer to make recommendations on what the college should do. One recommendation was to generate an aspirational values statement for the college; a statement that identifies the characteristics we want to see in our community and the values we want to hold to help all members of our community balance work and life in a healthy and positive way and in a way that promotes mental health and wellness. Indeed, this effort supports and complements the 4th pillar of our CEAS Strategic Vision to “enrich our professional environment”. We now seek endorsement of this statement of values from a wide range of faculty and staff so that we can use this statement to drive the creation of new policy, practices, and programs that prioritize mental health and health-seeking practices, and provide our students with the support they need to be able to tackle the challenges of higher education and engineering in manageable ways that allow them to be successful in achieving their academic and personal goals.

We here at the College of Engineering and Applied Science (CEAS) value one another as human beings first and embrace practices to support the health, wellness, and success of all CEAS community members. We prioritize the well-being of all members of our community -- students, faculty, and staff. Community wellness begins with respect, empathy and inclusion, and we strive to develop well-balanced healthy individuals. We promote supportive conversations around mental health and health-seeking practices.

Engineering is a demanding curriculum where trial and error, taking risk, making mistakes, revising, correcting, and persisting is essential to learning. We help our community members find healthy and connected ways to learn from challenges and to productively integrate challenging experiences into their lives.

Recognizing that all students come from diverse backgrounds and follow different paths to get to CU, we strive to adopt academic policies and best practices for flexibility at both the course and program levels to support student well-being. We expect students to follow their own path at CU by taking ownership of their education, believing that personal responsibility is key to healthy living.

As faculty and staff, we strive to model the characteristics that we want to see in our students by being ethical, resilient, and creative educators and technologists, and prioritizing both our own health and well-being and the health and well-being of those around us. We share strategies with our students to grow intellectually, professionally, collaboratively, and personally.

We Hear You, We Value You, We C U!

We are Here for You.

### **COVID-19 Guideline for Fall 2021-Spring 2022**

As a matter of public health and safety due to the pandemic, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policy on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the “Accommodation for Disabilities” statement on this syllabus.

As of Aug. 13, 2021, CU Boulder has returned to requiring masks in classrooms and laboratories regardless of vaccination status. This requirement is a temporary precaution during the delta surge to supplement CU Boulder’s COVID-19 vaccine requirement. Exemptions include individuals who cannot medically tolerate a face covering, as well as those who are hearing-impaired or otherwise disabled or who are communicating with someone who is hearing-impaired or otherwise disabled and where the ability to see the mouth is essential to communication. If you qualify for a mask-related accommodation, please follow the steps in the “Accommodation for Disabilities” statement on this syllabus. In addition, vaccinated instructional faculty who are engaged in an indoor instructional activity and are separated by at least 6 feet from the nearest person are exempt from wearing masks if they so choose.

Students who have tested positive for COVID-19, have symptoms of COVID-19, or have had close contact with someone who has tested positive for or had symptoms of COVID-19 must stay home. In this class, if you are sick or quarantined, please let me know by email about your absence due to illness or quarantine. Because of FERPA student privacy laws, do not require students to state the nature of their illness when alerting you. Do not require "doctor's

notes" for classes missed due to illness; campus health services no longer provide "doctor's notes" or appointment verifications.

## Tentative Lecture and Exam Schedule for Materials and Energy Balance Spring 2022

Date	Day	Topic	Reading
Class 1 – 1/10	M	Introduction, dimensional homogeneity	Ch. 1, 2.1-4
Class 2 – 1/12	W	Linearization, density	2.6,7, 3.1
Class 3 – 1/14	F	Mass, volume, chemical composition	3.1-3.3
1/17	M	No class	
Class 4 – 1/19	W	Pressure, manometers, processes	3.4-3.6, 4.1
Class 5 – 1/21	F	General balance, flowcharts	4.2-4.3a
Class 6 – 1/24	M	Basis, simple balances, DOF	4.3b,c,d
Class 7 – 1/26	W	Degrees of freedom analysis, simple balances	4.3 d,e
Class 8 – 1/28	F	Multiple unit balances	4.3e, 4.4
Class 9 – 1/31	M	Multiple unit balances, recycle	4.4,5
Class 10 – 2/2	W	Recycle, bypass	4.5
Class 11 – 2/4	F	Stoichiometry, limiting reactants, conversion	4.6 a,b
Class 12 – 2/7	M	Extent of reaction, equilibrium	4.6 b,c
Class 13 – 2/9	W	Reactive species, excess air	4.6 d, 4.7 a, b, d, e
Class 14- 2/11	F	Recycle, overall and single-pass conversion	4.7 f
Class 15- 2/14	M	Overall and single-pass conversion, purge	4.7 f
Class 16 – 2/16	W	Combustion	4.8
Class 17 – 2/18	F	Average density, Ideal gas law, real gases	5.1, 2, 3a, 5.4
Review session 1 for midterm # 1 (Dr. Chatterjee): 2/19, Saturday 10 AM -12 PM, Venue: A104 The Southwest door will be unlocked from 9:45am-12pm (entrance closest to A104).			
Class 18 – 2/21	M	Compressibility chart, review	5.4
Review session 2 for midterm # 1 (Paula): 2/21, Monday 6-8 PM, Venue: A108 We will keep the southwest doors (down the hall from A108), southeast, and main west doors open until 6:30 pm.			
<b>Midterm #1: 2/22</b>	<b>Tu</b>	<b>Tuesday, Feb 22<sup>nd</sup>, 6:30 - 8:30 pm, Venue: B115</b> <b>The southwest door will be open until 7 pm.</b> <b>Extended time: 5:30 - 8:30 pm, Venue: E1B11</b>	<b>Ch 1-4.7e</b>
Class 19 – 2/23	W	Phase diagram, water	6.1a, 2, 3
Class 20 – 2/25	F	Water, single component	6.3
Class 21 – 2/28	M	Mutlicomponent	6.4
Class 22 – 3/2	W	Multicomponent	6.4
Class 23 – 3/4	F	Solubility	6.5
Class 24 – 3/7	M	Ternary phase diagrams	6.6
Class 25 – 3/9	W	Introduction to Energy	7.1,2
Class 26 – 3/11	F	Closed and open systems	7.3,4

Class 27 – 3/14	M	Thermodynamic tables, energy intro	7.5,6
Class 28 – 3/16	W	Mechanical energy balances	7.6,7
Class 29 – 3/18	F	Balances on non-reactive processes	8.1,3
Spring break: Mar 21st to Mar 25 <sup>th</sup> 2022			
Class 30 – 3/28	M	Sensible heat, heat capacities	8.3
Class 31 – 3/30	W	Phase Changes	8.4 a ,c
Class 32 – 4/1	F	Phase changes, psychrometric chart	8.4 a, c, d, e
Review session 1 for midterm # 2 (Dr. Chatterjee): Saturday, 4/2, 10 AM-12 PM, Venue: A104 <b>The Southwest door will be unlocked from 9:45am-12pm (entrance closest to A104).</b>			
Class 33 – 4/4	M	Psychrometric chart	8.4 d, e
Review session 2 for midterm # 2 (Paula): Monday, 4/4, 6-8 PM, Venue: B115 <b>We will keep the southwest door open until 8 pm (entrance closest to A104).</b>			
Class 34 – 4/6	W	Heats of reaction, Hess's Law	9.1,2
<b>Exam 2 (4/7)</b>	<b>Th</b>	<b>Tuesday, April 7<sup>th</sup>, 6:30 - 8:30 pm, Venue: A104</b> <b>The southwest door will remain open until 6:45 pm</b> <b>Extended time: 5:30 - 8:30 pm, Venue: B115</b>	<b>Ch. 1-8.3</b>
Class 35 – 4/8	F	Heats of formation, heats of combustion	9.3,4
Class 36 – 4/11	M	Heat of reaction method	9.5a
– 4/13	W	Heat of formation method	9.5a
Class 37 – 4/15	F	Compare the two methods	9.5a
– 4/18	M	Simultaneous material and energy	9.5b
Class 38 – 4/20	W	Heating value, adiabatic flame	9.6
–4/22	F	Mixing and solution	8.5
Class 39 – 4/25	M	Thermochemistry of solutions	9.5c
Review session – 4/27	W	Catch-up day and Review session	
Review session for Final (Dr. Chatterjee): 4/27, Wednesday 1-3 PM, Venue: A115			
Review session for Final (Paula): 4/29, Friday 6-8 PM, Venue: A104 <b>The southeast, southwest, and main west doors will remain open till 8 pm</b>			
4/27	F	Reading day (No class)	
<b>Final Exam (5/3)</b>	<b>Sunday</b>	<b>May 4<sup>th</sup>, 1:30-4:00 PM, Venue: A104</b> <b>The southeast, southwest, and main west doors will remain open</b> <b>Extended time: 12:00-4:00 PM, Venue: E125</b>	<b>Ch. 1 - 9</b>