

# Material and Energy Balances

**ECH 3023 Class #12193, Section 146C AND Class #12194, Section 15C1**  
**Class Periods: MWRFF; Period 4 (10:40 AM – 11:30 AM) OR Period 5 (11:45 AM – 12:35 PM)**  
**Locations: Period 4: M-PSY130, W-PSY130, R-NRN1037, F-FLG285;**  
**Period 5: M-LAR330, W-FLG260, R-NRN1037, F-PSY151**  
**Academic Term: Fall 2021**

## A quick word of advice

Material and Energy Balances (MEB) is the first class in the curriculum of Chemical Engineering. This course will introduce you to ideas, concepts, equations, and processes that you will **repeatedly** revisit in finer detail in later ChE courses. Therefore, it is essential that you work hard to master the material, because subsequent courses will build on the foundation established here.

Most concepts in MEB might not seem difficult to understand at face value. However, the difficulty in this class lies in the *application* of these concepts in order to solve problems. While your core science and math courses relied heavily on rote memorization to teach you the mechanics of problem-solving, this course will test your ability to apply old information in new situations.

The people that you meet in this class will become your colleagues for the remainder of your ChE education and beyond. I suggest that you meet and interact with as many of your classmates as possible, even if you are introverted. You are encouraged to work and study in groups and help each other as much as possible (in compliance with principles of academic honesty; see below).

## Instructor: VJ Tocco

I prefer that you call me “VJ”, but you may also call me “Dr. Tocco” if you are more comfortable addressing your instructors formally.

**E-Mail: [vjtocco@ufl.edu](mailto:vjtocco@ufl.edu)**

E-mail/canvas messaging is my preferred method of communication outside of class time. If using e-mail, you must use your ufl e-mail address.

**Office: 322 Black Hall, (352) 294-1290**

I do not plan to be available for in-person meetings in my office unless necessary.

**Office Hours (via zoom):** Tuesday 2-3 PM, Thursday 1-2 PM.

## Supervised Teaching Student: Ruwen Tan

Email: [ruwentan@ufl.edu](mailto:ruwentan@ufl.edu)

Office: 226 Chemical Engineering (Please do not come to this office unannounced)

Office hour (via zoom): **TBD**

## Course Description

(4 credits) Formulation and solution of material and energy balances utilizing physical/chemical properties of matter as applied to analyzing unit operations systems.

## Course Pre-Requisites / Co-Requisites

**Prerequisites:** CHM 2046 (General Chemistry), MAC 2312 (Calculus 2) and PHY 2048 (Physics 1)

**Co-requisites:** PHY 2049 (Physics 2), MAC 2313 (Calculus 3), and MAP 2302 (Differential Eq.)

## Course Objectives

Broadly, at the end of this course, a student should be able to do the following:

- 1) Perform basic chemical engineering calculations, including (but not limited to) unit conversions, mass/mole conversions, balance chemical reactions, interpolate tabulated data...
- 2) Draw and label a process flow diagram from a written description of a process.
- 3) Perform a degree-of-freedom analysis.
- 4) Derive and solve the equations needed to solve for unknown process variables.
- 5) Use Microsoft Excel to automate repeatable and tedious calculations.

In addition to these learning objectives, the assignments are designed to develop the following skills, which are characteristic of real-world problems, and therefore essential for any practicing chemical engineer:

- 1) Read, interpret, and follow directions, prompts, and problem statements.
- 2) Detect and disregard superfluous given information.
- 3) Use resources to find extra information which is needed, but not given.
- 4) Brainstorm reasons for unexpected behavior (troubleshooting).

## Materials and Supply Fees

None

## Professional Component (ABET):

Specific outcomes of instruction

- The student will be able to identify the unit operations involved in a process, draw process flowcharts for single- and multiple-unit operations, identify process variables, label process streams, and develop relationships between process variables for individual process units and complex processes common to chemical engineering practice.
- The student will be able to develop mass and energy balance equations necessary to solve reactive and non-reactive steady-state and transient systems by hand.
- The student will be able to perform simple degree-of-freedom analysis to identify the number of unknowns relating total mass and energy, mass and energy flow rates, and mass composition.
- The student will be able to use fundamental thermodynamic relationships (equations of state, phase equilibria, vapor pressure) as well as empirical thermodynamics relationships (Raoult's law, Henry's law, Antoine equation), and apply these to the solution of mass and energy balance problems.
- The student will be able to report engineering calculations and problem solutions in a professional manner.

## Relation to Program Outcomes (ABET):

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

## Course Format

All required course materials and resources (except the textbook) for ECH 3023 are contained on, or linked from, the course **Canvas page**. It will also serve as the primary means of communication with your classmates and instructors outside of class. You should get into the habit of checking this Canvas page regularly for announcements and action items. You should also enable Canvas to send you e-mail notifications, such that you are alerted to any updates or correspondence (the default state is "on", so no action is required unless you've disabled this feature).

The general format of ECH3023 in the Fall 2021 term will be "flipped", meaning that class sessions will focus on guided problem solving. Core course content will be delivered in a series of short, pre-recorded videos that you will be expected to view and study prior to class. A list of videos, their links, and the expected completion date will be posted on Canvas and/or announced during the preceding class.

### In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet,

or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

### Required Textbook

Elementary Principles of Chemical Processes (4th Ed.) by Felder, Rousseau, and Bullard; Wiley, ISBN 13:978-0-470-61629-1

*Note: This textbook is widely regarded by practicing Chemical Engineers as one of the most helpful and well-written Chemical Engineering textbooks. Although readings will not be assigned for credit, you may find that reading the textbook is essential in order to perform well in this course. The textbook also contains many useful tables of physical data. You may use another edition of the textbook, but keep in mind that is your responsibility (and your responsibility alone!) to determine the differences between your edition and the 4th edition.*

### Required Software

**Microsoft Excel** will be needed for some homework assignments. Therefore, you will need access to this software on your personal laptop.

### Recommended Materials

Any model of scientific calculator may be useful for solving homework and exam problems.

## Course Schedule (approximate and tentative)

Week	Topic(s)
1	Course Introduction, Chemical Processes, Data Fitting, Pressure
2	Process Variables, Process Classification, Process Flow Diagrams
3	Material balance calculations, Single-Unit Processes, Multiple-Unit Processes
4	Recycle/Bypass, Stoichiometry, Reactive Systems
5	Combustion Reactions
6	Ideal Gas Law, Single-Phase Systems, Introduction to Phase Equilibrium
7	Multiphase Systems, Txy & Pxy Diagrams
8	Introduction to Energy Balances
9	Thermodynamic Data Tables, Mechanical Energy Balances
10	Non-reactive Systems Involving an Energy Balance
11	Nonreactive Energy Balances
12	Reactive Energy Balances
13	Chemical Engineering Ethics and Safety
14/15	Unsteady-State Processes
15/16	Review, Course Debrief, and Outlook

### Attendance Policy and Expectations

Attendance will not be officially monitored or graded, but you are expected to attend and participate in all meetings. You are required to watch all course content videos at your own pace, but in advance of class meetings.

When interacting with fellow students and instructors (whether in-person or online), you are expected to maintain professionalism and behave respectfully. The community of ECH 3023 will be supportive and inclusive. Offensive imagery and/or language will not be tolerated in any capacity.

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:

<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

### Evaluation of Grades/Course Assignments

**Exams: 6 exams, 100 Points each; top two scores multiplied by 1.5x (70% of total grade)**

All exams are open-resource (books, notes, computational tools and online reference material), and will therefore not be proctored with HonorLock or ProctorU. However, you are **not** permitted to consult with any other person (or work done by other people) in any capacity while completing exams. This includes, but is not limited to: communication with classmates or previous ECH 3023 students and searching for/referencing solutions online or from previous semesters.

Each exam will last 90 minutes, with a 15-minute grace period for scanning and uploading solutions to Canvas. The exams are not necessarily cumulative, however, material from each section builds upon skills and concepts learned in previous chapters. The primary focus will be on material covered since the last exam, but may also include previous topics.

The format of the questions will vary, but expect a range of “easy” (roughly 30%), “medium” (roughly 40%) and “challenging” (roughly 30%) parts, with the point values for each question/part clearly labeled.

### **Exam dates:**

Thursday, September 16, 8:20 PM – 9:50 PM

Thursday, October 7, 8:20 PM – 9:50 PM

Thursday, October 21, 8:20 PM – 9:50 PM

Thursday, November 4, 8:20 PM – 9:50 PM

Thursday, November 18, 8:20 PM – 9:50 PM

Tuesday, December 7, 8:20 PM – 9:50 PM

**These exam dates are subject to change, with at least 2 weeks of notice. If you have a conflict (another exam) during any of these times, please notify your instructor ASAP.**

### **Homework: 6 assignments, 40 points each (low score dropped; 20% of total grade)**

Homework will be assigned approximately biweekly, and due (usually, but not always) on non-exam Thursdays.

Expect the homework problems to challenge you. VJ will answer direct, well-articulated questions relating to the homework, but will not guide you through the solution, troubleshoot your mistakes, or check your answers before submission.

In completing the homework assignments, you may not seek, possess, use, reference, or look at any work or solution (in part or in whole) that was not developed by you. This includes, but is not limited to, previous students assignments, work developed by classmates, and solutions on online websites (like Chegg or Course Hero). Posting homework problems online and/or looking at solutions on these websites is a violation of academic honesty.

However, you are permitted to discuss (verbally) the problems and problem-solving strategies with your classmates, provided that you remain within the boundaries of the academic honesty policy. I recognize that these boundaries of academic honesty can sometimes be difficult to navigate, and if you are ever unsure what is/is not allowed, you are highly encouraged to ask your instructor (before partaking!).

**Solution Submission:** Homework is to be submitted electronically on Canvas. Your homework solution must include the problem statements, with all requested answers reported in the answer box(es) provided.

A good problem solution primarily consists of a description of problem-solving logic in complete sentences, with equations to supplement the logic. Your work should be organized neatly and be easy to read and follow. You may type your solutions, but equations must be typeset with the “Equation Editor” in Word (or equivalent in another program). Because this can become quite time-consuming, I recommend hand-writing your solutions.

There are several free smartphone apps that can scan your work and convert it to a PDF (such as “CamScanner”). Photographs (learn the difference between a PDF and a photograph) are not acceptable. Please let VJ know if access to this technology is unavailable, and accommodations will be made.

**Due Date:** Homework is due at 11:59 PM on Thursdays and graded *as submitted*. Late homework will be accepted, without penalty, a maximum of **two days** after the due date (i.e. Saturdays at 11:59 PM).

**Low Score Drop:** Each student's lowest homework score will be dropped at the end of the semester. This policy covers emergencies and technological issues alike, and no documentation or action is required of the student.

No further accommodations or deadline extensions for homework or quizzes will be granted due to technological issues or emergencies. You should anticipate that these issues will arise at the worst possible time (for example, wifi always seems to crash 10 minutes before the homework is due), and plan contingencies.

**Significant progress must be demonstrated on a minimum of 70% of the homework problems in order to pass the course.**

### Team-Based Project: 100 Points

In the class project, you will work in assigned groups of 3-4 to compose and solve an original problem. More details will be given when the project is assigned later in the semester.

### Extra Credit: 10 Points Possible (due Monday, December 6)

Option 1: Write an original exam/homework problem. You must submit the **problem statement, an answer key, and an explanation of the concept** that the question is testing. In addition, by submitting these questions, you authorize me to use them in subsequent semesters (or, if the question is good enough, this semester!). You may submit as many questions as you like.

Option 2: Submit a creative expression of your experiences in ECH3023. Submissions may include a song, video, poem, craft, artwork, or any other creation. The only constraints are that your submission must be completely original, and your submission must be **shared** with the rest of the class on the last day of class.

### Grading Policy

You may earn 1000 possible points in this course by completing assignments (see above). Your final letter grades will be based on your final point total only (no curve). The thresholds to earn a given letter grade are listed below:

Point Value	Letter Grade
900-1000	A/A-
800-899	B+/B/B-
720-799	C+/C
700-719	C-
600-699	D+/D/D-
<600	E

Determination of +/—/- letter grades will be based primarily on the distribution of student scores within the tier (with roughly 1/3 in each bin). However, these may also be subject to instructor's discretion, considering professionalism, participation, effort, and performance trajectory. These decisions will be based solely on the instructor's discretion.

Note that departmental policy requires a grade of C or above in order to continue to the next courses in the curriculum.

More information on UF grading policy may be found at:  
<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

## Make-Up Policy

In the case of an emergency, technological issue, or excused absence during an exam, one **comprehensive** make-up exam will be offered at the end of the semester, provided that **adequate proof/documentation is presented in writing**.

Make-up work for extended excused absences will be considered on a case-by-case basis in a manner that is fair for you and your classmates. Excused absences must be consistent with university policies in the undergraduate catalog (<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>) and require appropriate documentation.

## Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

## Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

## University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (<https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

## Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, [jpennacc@ufl.edu](mailto:jpennacc@ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto:nishida@eng.ufl.edu)

## Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

## Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

## Campus Resources:

### Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

Sexual Assault Recovery Services (SARS)  
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

### COVID-19

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email [covid@shcc.ufl.edu](mailto:covid@shcc.ufl.edu)) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the [UF Health Screen, Test & Protect website](#) for more information.

- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

## Academic Resources

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).  
<https://lss.at.ufl.edu/help.shtml>.

**Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling.  
<https://www.crc.ufl.edu/>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.  
<https://teachingcenter.ufl.edu/>.

**Writing Studio, 302 Tigert Hall**, 846-1138. Help brainstorming, formatting, and writing papers.  
<https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus**: [https://www.dso.ufl.edu/documents/UF\\_Complaints\\_policy.pdf](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf).

**On-Line Students Complaints**: <http://www.distance.ufl.edu/student-complaint-process>.