

Fluid and Energy Transfer Operations Laboratory

ECH 4224L

Sections 055G (Mondays), 056A (Tuesdays), 2449 (Wednesdays), 3535 (Thursdays),
6342 (Fridays)

Class Periods: 2-5 (8:30 am – 12:35 pm)

Location: Unit Operations Lab (CHE 100-300)

Academic Term: Spring 2019

Instructor: Prof. Fernando Mérida

Office: CHE 229

Phone: 352-294-7504

E-mail: fmerida@ufl.edu

Office hours: Monday and Wednesdays, 2:00 pm to 3:30 pm or by appointment.

Peer Tutors:

| | |
|------------------|----------------------------------------------------------------|
| Sarah Colburn | sacolburn16@ufl.edu |
| Andrew McBride | mcbri1at@ufl.edu |
| Matt Morlock | mmor2710@ufl.edu |
| Lauren Paschall | lauren4463@ufl.edu |
| Uday Rallabhandi | udayr23@ufl.edu |
| Ines Reis | inesmsreis@ufl.edu |
| Alexis Schroeder | aschroeder22@ufl.edu |
| Sabrina Siu | sabrinasiu@ufl.edu |
| Ryan Trossevin | rtrossevin11@ufl.edu |
| Derek Wright | derekwright@ufl.edu |

Teaching Assistant:

| | |
|----------|----------------------------------------------------------|
| Yifan Yu | yifan2015@ufl.edu |
|----------|----------------------------------------------------------|

Assignment of peer tutors to individual experiments will be communicated through the Canvas website.

Course Description

Laboratory work in unit operations involving heat and momentum transfer; 2 credit hours.

Course Pre-Requisites:

ECH 3101 (Process Thermodynamics),

ECH 3203 (Fluid and Solid Operations)

ECH 3223 (Energy Transfer Operations)

ENC 3246 (Professional Communication for Engineers)

Course Co-requisite: ECH 4714L (Safety and Experimental Evaluation)

Materials and Supply Fees: \$100.24

Course Objectives

1. Reinforce classroom theory by the collection and use of data in practical experiments with all their inherent problems and limitations.
2. Gain proficiency in writing technical reports and oral presentations.
3. Gain experience in working in teams.
4. Create a sense of professional responsibility for the quality and integrity of engineering work.
5. Learn safe working procedures.
6. Learn equipment, instrumentation, and procedures not covered in lectures.

Professional Component (ABET):

This course is focused on experimental studies of thermodynamics and heat and momentum transfer in the context of unit operations. Theoretical concepts learned in other courses are illustrated by experiments. Technical communications are emphasized.

Relation to Program Outcomes (ABET):

| Outcome | Coverage* |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| (a) an ability to apply knowledge of mathematics, science, and engineering | <i>High</i> |
| (b) an ability to design and conduct experiments, as well as to analyze and interpret data | <i>High</i> |
| (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability | <i>Medium</i> |
| (d) an ability to function on multi-disciplinary teams | <i>Medium</i> |
| (e) an ability to identify, formulate, and solve engineering problems | <i>High</i> |
| (f) an understanding of professional and ethical responsibility | <i>Medium</i> |
| (g) an ability to communicate effectively | <i>High</i> |
| (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context | |
| (i) a recognition of the need for, and an ability to engage in life-long learning | <i>Medium</i> |
| (j) a knowledge of contemporary issues | |
| (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice | <i>High</i> |
| (l) a recognition of industrial health and safety issues, and an ability to engage in fostering and exercising health and safety rules and regulations | <i>High</i> |

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not part of the course.

Unit Operations Lab Website: <http://ww2.che.ufl.edu/unit-ops-lab//ech4224L.htm>

Contains descriptions of experiments, safety guidelines, and guidelines for writing reports.

Canvas website (<http://elearning.ufl.edu/>) will be used for submission of reports and posting of grades and announcements.

Recommended Literature

1. Geankoplis, C. J., *Transport Processes and Unit Operations* [On reserve in the Science Library].
2. Incropera, F. P. and D. P. DeWit, *Fundamentals of Heat and Mass Transfer* [On reserve in the Science Library]
3. McCabe, W. L., J. C. Smith, and P. Harriet, *Unit Operations of Chemical Engineering* [On reserve in the Science Library]
4. Perry, R. H., D. W. Green, and J. O. Maloney, *Perry's Chemical Engineers' Handbook* [E-book is available through UF Library website]

There is no required textbook for this class.

Module description:

- Module 1: Thin Film Evaporator (preliminary and final reports)
- Module 2: Fluids
 - Fluid flow in pipes (final report)
 - 2-rotameter experiment (postlab homework)
 - 3-tank experiment (postlab homework)
 - Tank draining (postlab homework)
 - Packed bed (postlab homework)
- Module 3: Filtration (preliminary and final reports)
- Module 4
 - Heat exchanger (final report)
 - Fluidized bed (final report)

Each module is three weeks long. Each course section is divided into groups of four or less students and the groups rotate through all four modules. Quizzes and pre-lab work will be required at the beginning of each module. During and after completion of each module the groups are required to submit lab reports and/or postlab homeworks, as indicated above. Each group is free to organize the workflow for their project. **Regardless of individual contributions, each team member is responsible for understanding all elements of each project.**

A full schedule showing the group-module distribution along the semester will be periodically updated and students will access it via Canvas website

Module workflow:

| | Module 1: TFE | Module 2: FLU | Module 3: FIL | Module 4: H&B |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| <i>Name</i> | <i>Thin Film Evaporator</i> | <i>Fluids</i> | <i>Filtration</i> | <i>Heat Exchanger and Fluidized Bed</i> |
| <i>Experiment nomenclature and schedule</i> | <ul style="list-style-type: none"> • Factor 1 (week 1) • Factor 2 (week 2) • Factor 3 (week 3) | <ul style="list-style-type: none"> • FF: Fluid Flow (weeks 1 and 2) • SFE: Small fluid experiments (week 3) <ul style="list-style-type: none"> ➢ 2R: Two-rotameter ➢ 3T: Three-tank ➢ TD: Tank draining ➢ PB: Packed bed | <ul style="list-style-type: none"> • BF: Batch filtration (week 1) • CF: Continuous filtration (weeks 2 and 3) | <ul style="list-style-type: none"> • HE: Heat exchanger (week 2 and 3) • FB: Fluidized bed (week 2 and 3) |
| <i>Pre-lab work and quizzes¹</i> | Yes | Yes | Yes | Yes |
| <i>Preliminary report²</i> | Experimental design for weeks 2 and 3 | | (Results from BF & predictions for CF) | |
| <i>Predictions²</i> | | FF | | |
| <i>Post-lab work³</i> | | SFE | | |
| <i>Final Report³</i> | Entire module | FF only | Entire module | Two reports: 1. HE 2. FB |

¹ Due: the day a new experiment or module begins. This is an individual assignment.

² Due: two days before experiments of week 2 of the corresponding module. This is a group assignment.

³ Due: one week after the last lab session. This is a group assignment.

Attendance Policy, Class Expectations, and Make-Up Policy

Students are required to attend all lab sessions. 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. To make up for a missed lab, the students will be required to perform the missed experiment with another group. Unexcused absences and tardiness will result in a grade reduction.

Evaluation of Grades

The grade will be determined according to the following weighting criteria:

- Group assignments (lab reports and postlab homework): 70 %
- Prelab homework: 10 %
- Quizzes: 10 %
- Participation: 10 %

The participation grade will be based on the Peer Tutor feedback, peer evaluations, and the instructor's observations. **A failing grade for participation will result in a failing course grade.**

Grading Policy

| Percent | Grade | Grade Points |
|----------------|--------------|---------------------|
| 91.0 – 100.0 | A | 4.00 |
| 87.0 – 90.9 | A- | 3.67 |
| 83.0 – 86.9 | B+ | 3.33 |
| 79.0 – 82.9 | B | 3.00 |
| 75.0 – 78.9 | B- | 2.67 |
| 71.0 – 74.9 | C+ | 2.33 |
| 67.0 – 70.9 | C | 2.00 |
| 63.0 – 66.9 | C- | 1.67 |
| 59.0 – 62.9 | D+ | 1.33 |
| 55.0 – 58.9 | D | 1.00 |
| 51.0 – 54.9 | D- | 0.67 |
| 47.0 – 50.9 | E | 0.00 |

Important: Failure to follow safe operating procedures will result in a substantial grade reduction (see below).

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Safety

Students are expected to know and follow safe operating procedures of the equipment as well as proper handling of hazardous materials. The students are required to attend a safety orientation session at the beginning of the semester. **Failure to follow safe operating procedures will result in a significant grade reduction.** Examples of safety violations are listed below (this list is not exhaustive):

| Safety violation | Penalty |
|--------------------------------------------------------------------|------------------------|
| Leaving the lab without shutting down an experimental system | Failing grade |
| Not wearing PPE required by an experiment | Letter grade reduction |
| Not disposing of hazardous waste properly | Letter grade reduction |
| Not handling a chemical spill properly | Letter grade reduction |
| Causing a spill due to negligence (e.g., by opening wrong valves). | Letter grade reduction |
| Bringing food or drink into the lab | Letter grade reduction |

Prelab Homework Policy

- Prelab homework should be completed individually by each student and is due at the beginning of each new experiment.
- **A failing grade will be assigned to students whose cumulative prelab homework grade is less than 50%.**

- In addition to the homework assignment for each specific experiment, in the beginning of the semester the students will be assigned a homework on safety (due before your 1st lab session) and a homework on statistical analysis (due before your 2nd lab session).
- Late homework submissions will be accepted only if a student was not able to complete the homework on time due to an acceptable reason (see the attendance policy).

Quiz Policy

- **A failing grade will be assigned to students whose cumulative quiz grade is less than 50%.**
- **Failure to correctly answer safety-related questions will result in a 5% reduction of the course grade per each wrong answer.**
- Quizzes are scheduled at the beginning of each experimental session.
- Quizzes will be rescheduled only for those students who missed them due to an acceptable reason (see the attendance policy). It is required that whenever possible the student notifies the instructor about the situation before the quiz.
- Students arriving late for a quiz will be given only the balance of time remaining to complete their work unless an acceptable reason (see above) is provided.
- Students may not use their notes, manuals, or any other material during the quizzes.

Schedule for each experiment

Before the experiment:

1. Review theory, safety manual, and operating instructions posted on the Lab website.
2. If necessary, meet with the instructor to discuss the upcoming experiment.
3. Answer pre-lab questions posted on the Lab website. Written answers to the pre-lab questions should be submitted to your Peer Tutors at the beginning of the lab session.

During the experiment:

1. Get acquainted with equipment.
2. Learn proper start-up and shutdown procedures.
3. Learn how to perform measurements.
4. Learn about limits of the system.
5. Experiment with the system under various conditions.
6. Perform basic checks of your data (e.g., mass and energy balances) during the experiment. Avoid a situation in which you collect data just to discover that it does not satisfy the mass or energy balance **after** you are out of the lab and writing your report. It is necessary to perform the basic checks **during** the lab and repeat an experiment, if necessary.
7. Your preliminary analysis will be reviewed by the Peer Tutors and will contribute to your lab participation grade.

After the experiment:

Analyze your data and write a report or a postlab homework. All reports and postlab homeworks are group assignments. You are required to submit the following:

1. **Preliminary reports** for the Thin Film Evaporator and Filtration experiments. These reports should be submitted **at least 2 days before the 2nd lab session** of the corresponding experiment.
2. **Final report** for each of the following experiments: Thin Film Evaporator, Fluid Flow in Pipes, Filtration, Heat Exchanger, and Fluidized Bed.
3. **Postlab homework** for each of the small fluids experiments (2 Rotameters, 3 Tanks, Tank Draining, and Packed Bed)

The final reports and postlab homeworks are **due one week after the last lab session** of the experiment.

Guidelines for the Lab Reports

1. Detailed guidelines and grading rubrics are posted on the Lab website. Reports will be graded on both technical content and communication effectiveness.
2. Reports should be written using complete sentences, with correct spelling and grammar. All symbols should be defined on their first use. Clarity and brevity will be rewarded; sloppy thinking and writing will be penalized.
3. Do not copy theoretical derivations from a textbook or a website. Instead, clearly state assumptions behind a derivation, provide relevant derivation results, and cite your sources.
4. All reports should be submitted via e-learning either in MS Word or PDF format. There is no need to submit hard copies.
5. In addition to a report file, your submission should contain all supporting information, such as spreadsheet files with your data and files with your computer codes. However, your reports should be self-contained, i.e. one should be able to understand your work by reading your report without referring to supporting materials.
6. **Late submissions will be penalized by a 10% grade reduction for each day the report is overdue.**

Guidelines for Experiments and Data Analysis

1. Check energy and material balances.
2. Investigate effects of all control parameters on the experimental results.
3. Almost all experiments should be performed at a steady state. Exceptions are the batch filtration and the 3-tank experiments.
4. Clearly identify and justify all assumptions in your theoretical calculations.
5. Compare the measured data with your theoretical calculation.
6. Check reproducibility of your data. Whenever possible, **perform at least three runs for each experimental condition** and obtain error estimates by computing standard deviations based on these runs. Report the average values and error estimates in the main text of the report and provide an appendix containing data for all experimental runs.
7. Report any anomalous results and discuss their possible sources.

8. Use spreadsheets (e.g., Excel or OpenOffice) to store your data. Use Python (or another equivalent programming language) for data analysis and theoretical calculations. Use of spreadsheets for complex calculations is discouraged due to difficulty of their debugging.
9. Make sure that your objectives can be met with your operating conditions. It is easy to choose conditions that are outside of the performance limits of the apparatus or produce results with no measurable difference. Carefully study the limitations of the existing experimental apparatus as a part of the planning process rather than finding out in the laboratory that the experimental values obtained are useless.

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://www.dso.ufl.edu/sccr/process/student-conduct-honor-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.

Cooperation Policy

- Students are expected to work in teams on their experiments, reports, and postlab homework.
- Pre-lab questions should be answered by each student individually.
- No consultation among students is allowed during quizzes.

Plagiarism

Students are not permitted to represent as their own work any portion of the work of another person. Plagiarism includes (but is not limited to) submitting a document or assignment which in whole or in part is identical or substantially identical to a document or assignment not authored by the student. **All sources used in preparation of the reports should be cited.**

Falsification of Information

Students are not permitted to use or report any invented or fabricated information or data. This includes both experimental results and theoretical calculations.

Sanctions for Violations of Honor Code

Since ethical behavior in science and engineering is equal in importance to specific knowledge, the instructor will assign a *non-passing letter grade* to students who violate academic honesty standards, regardless of the violator's grade performance in class.

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 feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu/evals>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

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: <http://registrar.ufl.edu/catalog0910/policies/regulationferpa.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 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 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/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to 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.

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