Elementary Transport Phenomena

ECH 3264 Class # 26908
Class Periods: MWF Period 4, (10:40 AM - 11:30 AM)
Location: MWF: NEB 0202
Academic Term: Spring 2024

Instructor: Prof. Richard B. Dickinson.
dickinso@ufl.edu 352-235-4494
Office Hours: Monday 12-1 pm; Wednesday 12–1 pm; 493 Wertheim Lab or by appointment

Supervised Student Instructor: Siddharth Sambamoorthy siddhartsambamoo@ufl.edu
Office Hours: 4-5 pm Tuesday,

Supervised Undergraduate Tutor: Ian Lange ianlange@ufl.edu
Office Hours: TBD

Course Description
Flux law and conservation equations of mass, energy and momentum; steady and unsteady states as applied to physical and chemical processing; macroscopic and microscopic analysis.

Course Pre-Requisites / Co-Requisites
Pre-requisites: ECH 3023, MAP 2302, and MAC 2313.

Course Objectives
Upon completion of this course, a student should be able to:

- Derive differential equations from basic conservation principles describing heat, mass, and momentum
- transport
- Define and utilize Fourier's Law and Fick's Law
- Define the characteristics of Newtonian and Non-Newtonian Fluids
- Define and explain the origins of the quantities (such as heat transfer coefficient, viscosity, and diffusivity) used to describe heat, momentum, and mass transport
- Use the equations of change to formulate differential equations with proper boundary conditions to describe transport phenomena
- Solve one-dimensional steady problems of mass, momentum, and heat transport with or without source terms
- Solve selected multidimensional problems of mass, momentum, and heat transport with and without source terms

Materials and Supply Fees
N/A

Required Textbook:
R. B. Bird, W. E. Stewart, E. N. Lightfoot, *Transport Phenomena*, 2nd Edition, Wiley, 2002
ISBN: 0-470-11539-4

Attendance Policy, Class Expectations, and Make-Up Policy
While attendance is not monitored, be aware that regular attendance is essential to succeed in this course. Quizzes and exams missed due to unexcused absence will counted as zero in the final grade. Make up quizzes and exams will be provided for excused absences (per UF attendance policies linked below). Students must notify of planned excused absences as far in advance as possible. Please notify the instructor as soon as possible in the event of a missed quiz or exam due to illness or emergency.
https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/

Course Schedule (Tentative):

Wk	Day	Date	Topic	Reading	HW Due
1	M	Jan 8	Course Overview		
	W	10	Transport Rate Laws	1.1; 9.1; 17.1	
	F	12	Energy Transport	9.2,9.3	
2	M	15	**Holiday**		
	W	17	Energy shell balance	10.1	
	F	19	Energy shell balance - **Quiz 1**	10.2	
3	M	22	Boundary Conditions	10.2	
	W	24	Cylindrical Problems –	10.3	**1**
	F	26	Spherical Problems **- Quiz 2**	10.6	
4	M	29	Cooling Fin	10.7	
	W	31	Momentum Transport	1.2	**2**
	F	Feb 2	**EXAM 1**		
5	M	5	Momentum Transport	1.3	
	W	7	Vectors and Tensors	A.1-4	
	F	9	Newton's Law in 3D	1.7	
6	M	12	Momentum shell balance	2.1	
	W	14	Momentum boundary conditions	2.2	**3**
	F	16	**Review & Quiz 3**		
7	M	19	Momentum shell balance with gravity		
	W	21	Flow in a cylindrical tube	2.3	**4**
	F	23	Flow in an annulus - **Quiz 4**	2.4	
8	M	26	Flow around a sphere	2.6	
	W	28	Equations of Change	3.1	**5**
	F	Mar 1	**EXAM 2**	3.2	
9	M	4	Equations of Change	3.5	
	W	6	Navier-Stokes Equation		
	F	8	Solving flow problems	3.6	
10	M-F	11-15	**Spring Break**		
11	M	18	Solving flow problems		
	W	20	Dimensional Analysis	3.7	**6**
	F	22	**Review & Quiz 5**		
12	M	25	Solving flow problems		
	W	27	Turbulent Flow	5.1	**7**
	F	29	Mass Transport - **Quiz 6**		
13	M	Apr 1	Convective mass transport	17.3	
	W	3	Mass transport shell balance	17.7; 17.8	**8**
	F	5	**EXAM 3**	18.1	
14	M	8	Boundary conditions	18.2	
	W	10	Diffusion with heterogeneous reaction	18.3	
	F	12	Diffusion with homogeneous reaction		
15	M	15	Diffusion with convection	18.4	
	W	17	Unsteady problems	18.5	**9**
	F	19	**Review & Quiz 7**	12.1	
16	M	22	Unsteady problems	41	
	W	24	Unsteady problems **Quiz 8**	9.7; 10.5	**10**
	Tu	Thu 2	**EXAM 4** 7:30-9:30 am		

Evaluation of Grades

Assignment	Points	Percentage of Final Grade
Homework Sets (10)	100 each	12%
Quizzes (8)	100 each	24%
Exams (4)	100 each	64%

Grading Policy

Percent	Grade	Grade Points
100 - 92	A	4.00
91.9 - 88	A-	3.67
87.9 - 84	B+	3.33
83.9 - 80	B	3.00
79.9 - 76.0	B-	2.67
75.9 - 72.0	C+	2.33
71.9 - 68.0	C	2.00
67.9 - 64.0	C-	1.67
63.9 - 60.0	D+	1.33
59.9 - 56.0	D	1.00
55.9 - 52.0	D-	0.67
51.9 - 0	E	0.00

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

Homework: Homework (HW) is submitted via CANVAS in a single PDF document. Late HW will be accepted with a 30% deduction for each day late (up to 2 days). Each HW assignment is equally weighted. HW must be prepared neatly, professionally, and per instructions to receive full credit. Include your name, date, and HW number on the first page. Use straightedge, template, or computer-generated lines and shapes for all diagrams. Solutions will be posted on CANVAS. Students are encouraged to help each other on HW, but copying someone else's solution or allowing someone else to copy yours is cheating and a violation of academic honesty policy. Rule of thumb: Discuss the HW and help each other, but don't look at anyone else's work or show them your work.

HW problem scoring (out of maximum five pts): 4 pts: Correct answer showing work. 3 pts: Nearly correct with minor calculation error(s); 2 pts: Significant attempt, but wrong approach; 1 pt: Minimal attempt, or answer without supporting work. +1 point for neatness and professional presentation following the above guidelines. HW problems may be weighted differently when calculating the overall HW assignment score due to variability in effort required.

Exams: There will be four equally weighted exams at the dates listed on the schedule.

Quizzes: Eight CANVAS quizzes will be given on Fridays (see Schedule). The quizzes will generally cover lecture material from the previous few class periods since the last quiz or exam and will require 10-15 minutes to complete. Solutions will be posted on CANVAS.

Relation to Program Outcomes (ABET):
Course objectives (1)-(7) are linked to student outcome 1.

Outcome	Coverage
1. identify, formulate and solve complex engineering problems by applying principles of engineering, science, and mathematics	High

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, 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/.

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.

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/process/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
- HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, 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 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: https://counseling.ufl.edu, 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

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 suppor*t*, 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://career.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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

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