

## Biomedical Engineering Transport Phenomenon

BME 4632 Section 1854

**Class Periods:** Monday, Wednesday, and Fridays Period 5 (11:45 AM – 12:35 PM)

**Location:** TUR 2319

Zoom link: <https://ufl.zoom.us/j/92947679940?pwd=TEZuWmtaMUJMbZV6UTBXNEp4MzhkUT09>

**Academic Term:** Fall 2021

### **Instructor:**

**Name:** Prof. Benjamin Keselowsky

**Email Address:** [bkeselowsky@bme.ufl.edu](mailto:bkeselowsky@bme.ufl.edu)

**Class Sessions:** In person, TUR 2319, and simultaneously online.

Monday, Wednesday, and Fridays 11:45 AM – 12:35 PM

Zoom link: <https://ufl.zoom.us/j/92947679940?pwd=TEZuWmtaMUJMbZV6UTBXNEp4MzhkUT09>

**Office Hours:** Monday 4-5:00, Friday 3-4:00,

Zoom link: <https://ufl.zoom.us/j/93564736464?pwd=bGpFRElPUFQzYVNMZU5TVEITQ2d6UT09>

### **Supervised Teaching Student:**

Please contact through the Canvas website.

- Office hours: Wednesday 4:00 PM
- Zoom link: <https://ufl.zoom.us/j/96783114461?pwd=ekNWMERET21Xc0FkY2pzSHRTYzR6dz09>
  - Adrienne Widener, [adriennejan25@ufl.edu](mailto:adriennejan25@ufl.edu)
  - Arin Lampejo, [alampejo@ufl.edu](mailto:alampejo@ufl.edu)

### **Course Description**

Introduction to and application of the concepts of momentum, mass, and thermal energy transport in the context of problems of interest in biomedical sciences and engineering. Macroscopic and microscopic analysis of momentum, mass, and thermal energy transport problems in biomedical systems. 3 credits

### **Course Pre-Requisites / Co-Requisites**

Pre-Req: BME 3060 (Biomedical Fundamentals) with minimum grade of C.

### **Course Objectives**

1. Students will understand the relationship between blood flow and physiological function and dysfunction in the surrounding tissues and organs.
2. Students will be able to solve transport equations using methods from advanced mathematics.
3. Students will become comfortable applying fundamental bio-transport fundamentals to the design and interpretation of experiments.
4. Students will develop an intermediate/advanced understanding of trans-endothelial transport and oxygen delivery to tissues and organs.
5. Students will be able to apply dimensional analysis to the equations for the problems in fluid transport.
6. Students will learn about receptor-ligand kinetics and how to apply the kinetic models to study cell adhesion and intracellular signaling.

### **Professional Component (ABET):**

This course will prepare students to apply advanced mathematics to solve problems at the interface of engineering and physiology. Specific to the UF BME program educational outcomes, students will gain experience applying a knowledge of biotransport fundamentals to solving open-ended biomedical engineering challenges related to therapeutic design and basic science discovery.

### **Required Textbooks and Software**

G.A. Truskey, F. Yuan, D.F. Katz, Transport Phenomena in Biological Systems, 2nd Edition. Pearson Prentice Hall, 2009. ISBN: 0-13-156988-8.

*Note: The textbook for this course, is available as a short-term loan to check out for 2 hours at a time at the Marston Science Library. Please visit the service desk and ask for the course reserve item for BME4632.*

**Software:** A means for solving systems of equations is required for completion of certain assignments (e.g., Matlab, graphing calculator, or Wolfram Alpha website).

**Topics Covered in this Course**

- Approaching problems from an engineering prospective
- Introduction to bio-transport problems
- Introduction to diffusion and convection
- Review of forces and fluid statics
- Newtonian fluids and shear/stain relationships
- Fluid transport: kinematics, conservation equations
- Fluidic applications: parallel-plate, rectangular and cylindrical channels
- Differential forms of the conservation of mass and momentum: Navier Stokes
- Integral forms of the conservation of mass and momentum
- Blood rheology
- Physiological and pathological blood flow and the cardiovascular system
- Dimensional analysis and scaling
- Mass transport: steady diffusion and boundary conditions
- Steady state diffusion from variable geometries
- Unsteady diffusion
- Transport in porous media
- Special Topics: Transvascular transport; Pharmokinetics; Drug delivery

**Relation to Program Outcomes (ABET):**

The following ABET learning outcomes are emphasized in this course.

<b>ABET Outcome</b>	<b>Coverage*</b>	
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High	Emphasized
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		
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		
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		
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	Medium	Reinforced
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Low	Reinforced

**Course Schedule:** Canvas will be used to post the course schedule and quiz/exam dates. The schedule is tentative and subject to change based on course progress and student needs.

**Meeting Course Objectives:**

The course objectives will be achieved through: lectures, participation, handouts, website, assignments, and exams/quizzes.

**Lectures:** The lectures will reinforce important concepts or areas of information, outline derivations, and provide support for completion of homework assignments. Lectures will be supported by the primary textbook for the class, but other topics will be covered at the discretion of the instructor. Attendance is critical for success in this course.

**Participation:** You are highly encouraged to ask questions and participate in course problem derivations during class. In-class assignments, discussions, and questions will be offered to enrich learning and for in-class assignment credits or bonus points.

**Website:** Canvas (elearning.ufl.edu) will be used extensively to post relevant information on the course, including all assignments. All students are fully responsible for ensuring that they have access to the course website on Canvas and that they check this website or set up reminders to ensure they are fully aware of all postings. Failure to check this website will not be a valid excuse for not completing assignments. Grades will also be posted using Canvas as the course progresses.

**Assignments:** Given that a large amount of this class covers mathematics and engineering principles, in-class and homework assignments will be a critical component to this course. In-class assignments are used to reinforce covered material (lectures or from the book). For homework, you will generally be given 1 week to complete assignments. Independent completion of the homework is critical to success in this course. Homework assignments are due by the time indicated to be considered on time. As an online course, it is critical that you have a means to electronically submit your homework in a manner that is clearly legible. For electronic submissions, I will only accept a single PDF file containing clearly legible pages in correct sequence of the assigned work (problems in order) submitted via Canvas. Submissions that do not meet these requirements will not be graded and counted as 0 pts.

**Late homework** will be accepted up to 24 hrs after the deadline, but with a 15 pt penalty. Homework after this time frame will not be accepted for any excuse except a documented university approved absence. Note that homework is a considerable percentage of your grade, so make the completion of this a priority.

**Exams/Quizzes:** The format for examinations and the quiz may fluctuate as the course progresses, with variation in format and credit distribution (e.g. take home work, presentations, and in-class discussions).

### ***Online Course Recording***

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

### ***Attendance Policy, Class Expectations, Make-Up Policy, and Assistance***

**Attendance:** Attendance is not monitored, but is essential for success in this course. It is your responsibility to keep up to date on the materials/assignments when you have missed class. Please notify me in advance if you will be missing (or have missed) more than 2 consecutive classes, as I am here to help if you experience illness or an event that makes it challenging to keep up with course material.

**Communication:** Class announcements will be posted to Canvas and all students are responsible for ensuring awareness of these postings. Failure to review the course website is not an excuse for missing assignments, class time changes, etc. All students are expected to communicate in a professional manner. Contact me via Canvas only.

**Conduct:** All students are expected to conduct themselves in a professional manner when participating in this course. A student participating in conduct that is not supportive of the educational experience will be requested to terminate this activity or leave the classroom. Discussions should be conducted in a respectful and courteous manner, to encourage a dynamic interaction from all in attendance.

**Make-Up Policy:** Make up exams and/or quizzes will only be permitted for university approved absences. Please review your student handbook to ensure that you understand the requirements for a university approved absence. Excused absences are consistent with university policies in the undergraduate catalog (<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>) and require appropriate documentation.

Assistance with Course Material: You should expect this course to challenge you and require time, effort, and thoughtful analysis for success. When a concept or problem presents a challenge, spend the time to really think about how to approach the problem, as this thoughtful analysis will train you for success in exams (and future classes). If you are struggling with a concept or problem, you have 2 primary resources: 1) your peers and 2) your professor. Before you reach out to any of these resources, you are expected to have spent considerable time on your own attempting to understand or complete the problem.

Peers: Establishing a strong and fruitful peer network is an important resource in your major and will help serve you well as you progress in BME, so seek out colleagues that can serve as a strong peer network. Brainstorming on problems with your peer group (after you have attempted to solve them independently) is permitted; however, this dynamic interaction should be one that leads to improved conceptual understanding on how to approach problems – not one used as a crutch to copy solutions. Assignments are used to train you for exams, so copying solutions from friends will inevitably result in a poor exam performance. In the end, individual assignments must be your own work, not a copied solution. ***If copying of work on an individual assignment is evident, the problem will earn 0 credits.***

Professor: I am another resource to assist you in succeeding in this course. You are welcome to see me during my regularly posted office hours. Due to multiple demands, I am typically unavailable outside of these times, but can be reached via email (sent via Canvas). During office hours, I look forward to answering any questions that can help clarify a concept or provide a new perspective on how to approach a problem. When notes are left on assignments and exams to “see me”, this means that I would like to take extra time to work out concepts with you. I will leave it up to you, however, to initiate scheduling this meeting.

### ***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/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 STs in this class.

## Plagiarism

Plagiarism is the most common infraction to the UF Honor Code. If you are confused as to what constitutes plagiarism, see here: <https://guides.uflib.ufl.edu/copyright/plagiarism>. Plagiarism on any of your assignments **will automatically be reported to the Dean of Students as a UF Student Honor Code violation**. Also, note that **copying solutions for any assignment, regardless of the source (e.g. other students, pirated website solutions), will be treated as plagiarism**.

## Evaluation of Grades

	Percentage of Final Grade
Assignments	30%
Quiz (1)	10%
Exams (3, equal weight)	60%
<b>Total</b>	<b>100%</b>

To maximize your partial credit in grading:

1. Write legibly and do not crowd your work.
2. Construct a clear diagram, if appropriate.
3. Write the equations you are using in symbols before substituting in numbers.
4. Label all numerical quantities/values with units.
5. Box your final answer.

## Grading Policy

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

Final cumulative numerical grades will be rounded to the nearest tenth of a point. Curving of assignments is exceptionally rare and typically only due to the entire class missing a question. No extra assignments for additional credit are given in this course. There is no curving of final grades.

Note: In order to graduate, students must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). A grade of "C minus" is equivalent to a GPA of 1.67. For more information on grades and grading policies, please visit: <https://catalog.ufl.edu/ugrad/current/advising/info/academic-progress.aspx>

Grade challenges: We do our best to grade evenly and fairly, but mistakes in grading can happen. Requests to modify points on assignments, quiz, or exams must be submitted in writing to Dr. Stabler within 1 week from when the graded assignment was made available. The request should identify the question and provide clear justification/reasoning for the requested change. The instructor will then review the request and modify the grade, as necessary. For grade challenge requests, the instructor reserves the right to regrade the entire assignment, not just the points in question. The instructor also reserves the right to turn down unreasonable or frivolous grade challenge requests.

## 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.ua.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.ua.ufl.edu/public-results/>.

### **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 Undergraduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, [rbielling@eng.ufl.edu](mailto:rbielling@eng.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/>.

#### 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>.