

BMD_ENG 395/495
Cardiovascular Engineering and Technology
Spring Quarter 2025

Instructor: Prof. Igor Efimov, igor.efimov@northwestern.edu

Office hours: by appointment in person or via Zoom. Office: Simson-Querrey building, room 11-529, E Superior St, Chicago, IL. Email: igor.efimov@gmail.com

Lecture times and room: 8:00-9:20 AM, Tuesday and Thursday, Evanston, Tech ???

Prerequisites: BME 304 or instructor approval.

Learning Objectives:

1. Identify the most challenging unmet needs in cardiovascular health and communicate their research, engineering, diagnostic, therapeutic, and regulatory challenges.
2. Synthesize the advances in science and technology to envision new cardiovascular disease diagnostics and therapy approaches.
3. Improve critical analysis of up-to-date scientific publications, patents, federal grants, and regulatory applications.
4. Professionally communicate scientific hypotheses and technological approaches in the form of NIH R21 grant application or FDA 510K application.

Course Overview

This course will integrate fundamental scientific knowledge and engineering technological advances involved in cardiovascular medicine with an emphasis on the most challenging unmet clinical needs, such as heart failure, hypertension, ischemic disease, myocardial infarction, metabolic disease, atrial fibrillation, and sudden cardiac death. The course will introduce gene and cell therapies, computational cardiology, design of implantable and wearable devices, ablation of cardiac arrhythmias,

Assignments and grading:

Class participation	15%
Individual paper presentations	15%
Project presentation	30%
Final presentation and submission	40%

Class Format

The class will combine lectures, contemporary research paper presentations by students, and final presentations of individual projects written in the form of NIH R21 grants or FDA 510k applications.

Absence and Scheduling Policies

Unexcused absence from a class meeting results in a deduction of one percentage point from your total grade. If you need to miss a class, you should contact the instructor as soon as the conflict is identified and no later than 5 pm on the Monday prior to that class. (Reasons for excusable absence may include attendance at a scientific meeting.) If unwell, students should communicate with the instructor as soon as possible.

All students are expected to participate in the discussions of the main paper each week, and to ask questions of their peers in the student presentations throughout the quarter. In a large class, it may not be possible for everyone to contribute substantially to every class. However, students who consistently do not engage with the discussions may lose up to 3 points from their total grade.

Students will be randomly assigned to the paper presentations. You may swap your assigned paper with that of another student, with two restrictions:

- 1) All paper swapping must be approved by the instructor in the first week of the quarter, prior to the second class meeting.
- 2) Students should not be presenting material directly related to their dissertation work. In the spirit of fairness, students should be presenting on topics within human physiology that do not overlap with their doctoral research.

All students will present their final R21 grant or 510K application in either Week 10.

Academic Integrity

Students in this course are required to comply with the policies found in the booklet, "Academic Integrity at Northwestern University: A Basic Guide". All papers submitted for credit in this course must be submitted electronically unless otherwise instructed by the professor. Your written work may be tested for plagiarized content. For details regarding academic integrity at Northwestern or to download the guide, visit: <https://www.northwestern.edu/provost/policies/academic-integrity/index.html>

Accessibility

Northwestern University is committed to providing the most accessible learning environment as possible for students with disabilities. Should you anticipate or experience disability-related barriers in the academic setting, please contact AccessibleNU to move forward with the university's established accommodation process (accessiblenu@northwestern.edu; 847-467-5530). If you already have established accommodations with AccessibleNU, please let me know as soon as possible, preferably within the first two weeks of the term, so we can work together to implement your disability accommodations. Disability information, including academic accommodations, is confidential under the Family Educational Rights and Privacy Act.

Recording and sharing of class content

Unauthorized recording is unethical and may also be a violation of University policy and state law. Students requesting the use of assistive technology as an accommodation should contact [AccessibleNU](#). Unauthorized use of classroom recordings – including distributing or posting them – is also prohibited. Under the University's [Copyright Policy](#), faculty own the copyright to instructional materials – including those resources created specifically for the purposes of instruction, such as syllabi, lectures and lecture notes, and presentations. Students cannot copy, reproduce, display, or distribute these materials. Students who engage in unauthorized recording, unauthorized use of a recording, or unauthorized distribution of instructional materials will be referred to the appropriate University office.

Student Wellness

We are committed to supporting the wellness of our students. Student Affairs has multiple resources to support student wellness and mental health. If you are feeling distressed or overwhelmed, please reach out for help. Students can access confidential resources through the Counseling and Psychological Services (CAPS), Religious and Spiritual Life (RSL) and the Center for Awareness, Response and Education (CARE). Additional information can be found at:

<https://www.northwestern.edu/counseling/>

<https://www.northwestern.edu/religious-life/>

<https://www.northwestern.edu/care/>

Fall 2024 Class Schedule:

Week #	Date	Focus
1		Cardiovascular anatomy and multi-scale engineering of the CV system. Introduction to NIH R-grant and FDA 510k submissions
2		Genetic and gene regulatory network engineering. Genetic basis of cardiovascular diseases.
3		Cell engineering and reprogramming, tissue engineering. Presentation of ideas for R21 or 510k
4		Metabolic engineering. Neuro-cardiology of heart failure and arrhythmia.
5		Excitation-contraction coupling. Physics and biology of cardiac excitation and ECG.
6		Computational cardiology.
7		Electrical, mechanical, and optical stimulation. Cardiac pacing.
8		Heart failure and heart rhythm disorders and therapeutic strategies.
9		Implantable arrhythmia monitors and arrhythmia therapy.
10		Cardiac imaging and mapping modalities: MRI, CT, US, optical, OCT, PAT. Physics and biology of ablation therapy: energy delivery and tissue damage.
Exams		Final Project Presentations