NUCL597: Introduction to Bioelectrics

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Course Information
Spring 2019
TU/TH 1630-1745
EE 115

https://mycourses.purdue.edu/

Course Description

This course will introduce students to the fundamental physics, engineering, and biology involved in the interaction of intense electromagnetic radiation with biological cells, including pulsed electric fields, plasmas, and lasers.

Prerequisites (if needed)

None

Course Goals

1) Describe the electrical representation of a biological cell and use it to explain electromagnetic interactions.
2) Describe the hardware involved in electromagnetic actuation of biological cells.
3) Describe the applications of bioelectrics.
4) Apply mathematical modeling to describe the relevant physical and biophysical mechanisms.
5) Conduct an independent project on an area of bioelectrics culminating in a report and class presentation.

Learning Objectives

At the conclusion of the course, students will be able to (1) describe the fundamental interactions of intense electromagnetic interactions with biological cells and tissues, (2) discuss common applications of these technologies, (3) derive relevant biophysical relationships, and (4) apply these ideas to a simple research project.

Course Requirements

Homework Assignments (40%), Literature Review (20%), Class Project Report (25%), Class Project Oral Presentation (15%)

Optional Texts

1) S. Grimnes and O. G. Martinsen, *Bioimpedance and Bioelectricity Basics* 3rd Edition, Academic Press, 2014.
2) H. Akiyama and R. Heller, *Bioelectrics*, Springer, 2017.

3) A. G. Pakhomov, D. Miklavĉiĉ, M. S. Markov, Advanced Electroporation Techniques in Biology and Medicine, CRC Press, 2010.
4) Original literature.

Policies

General Course Policies

Class attendance is critical. We will introduce key fundamental concepts of biology and then introduce the relevant physics and engineering for understanding the interactions of intense nonionizing radiation on biological cells. While a background in electromagnetics and electrical biophysics is helpful, it is not required.

Grading

The course will consist of homework assignments, and independent research projects that include a literature review on a topic based on discussion with the instructor.

Purdue Honors Pledge: "As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue."

https://www.purdue.edu/provost/teachinglearning/honor-pledge.html

Academic Dishonesty

Please refer to Purdue's student guide for academic integrity (http://www.purdue.edu/purdue/about/integrity_statement.html)

Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section III-B-2-a, University Regulations] Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972]

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breeches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information that is submitted provides the greatest opportunity for the university to investigate the concern.

Use of Copyrighted Materials

Proper citations of any external sources must be noted. Additionally, the Unviersity policy is below:

Among the materials that may be protected by copyright law are the lectures, notes, and other material presented in class or as part of the course. Always assume the materials presented by an instructor are protected by copyright unless the instructor has stated otherwise. Students enrolled in, and authorized visitors to, Purdue University courses are permitted to take notes, which they may use for individual/group study or for other non-commercial purposes reasonably arising from enrollment in the course or the University generally.

Notes taken in class are, however, generally considered to be "derivative works" of the instructor's presentations and materials, and they are thus subject to the instructor's copyright in such presentations and materials. No individual is permitted to sell or otherwise barter notes, either to other students or to any commercial concern, for a course without the express written permission of the course instructor. To obtain permission to sell or barter notes, the individual wishing to sell or barter the notes must be registered in the course or must be an approved visitor to the class. Course instructors may choose to grant or not grant such permission at their own discretion, and may require a review of the notes prior to their being sold or bartered. If they do grant such permission, they may revoke it at any time, if they so choose.

Plagiarism

Plagiarism is defined in "Academic Integrity: A Guide for Students" (http://www.purdue.edu/studentsuccess/orientation/bgr/classroom/05-Wednesday%20Morning-Academic%20Integrity.pptm) as follows:

"Plagiarism is a special kind of academic dishonesty in which one person steals another person's ideas or words and falsely presents them as the plagiarist's own product. This is most likely to occur in the following ways:

- using the exact language of someone else without the use of quotation marks and without giving proper credit to the author
- presenting the sequence of ideas or arranging the material of someone else even though such is expressed in one's own words, without giving appropriate acknowledgment
- submitting a document written by someone else but representing it as one's own"

Any document that includes plagiarized materials **will receive a grade of zero.**

Attendance

Student attendance at the lectures is critical for learning the material.

Students are expected to be present for every meeting of the classes in which they are enrolled. Only the instructor can excuse a student from a course requirement or responsibility. When conflicts or absences can be anticipated, such as for many University sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible…For unanticipated or emergency absences when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email, or by contacting

the main office that offers the course. When the student is unable to make direct contact with the instructor and is unable to leave word with the instructor's department because of circumstances beyond the student's control, and in cases of bereavement, the student or the student's representative should contact the Office of the Dean of Students,

The link to the complete policy and implications can be found at https://www.purdue.edu/odos/sac/attendance-and-absence/.

Grief Absence Policy for Students

Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for misses assignments or assessments in the event of the death of a member of the student's family.

Violent Behavior Policy

Below is Purdue's policy prohibiting violent behavior. See the following website for additional information:
http://www.purdue.edu/policies/pages/facilities_lands/i_2_3.shtml

Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity.

Students with Disabilities

Purdue University is required to respond to the needs of the students with disabilities as outlined in both the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 through the provision of auxiliary aids and services that allow a student with a disability to fully access and participate in the programs, services, and activities at Purdue University.

If you have a disability that requires special academic accommodation, please make an appointment to speak with me within the first three (3) weeks of the semester to discuss any adjustments. It is important that we talk about this at the beginning of the semester. It is the student's responsibility to notify the Disability Resource Center (http://www.purdue.edu/drc) *of an impairment/condition that may require accommodations and/or classroom modifications.*

Emergencies

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised

semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructor via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

Counseling & Psychological Services (CAPS)

Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at (765)494-6995 and http://www.purdue.edu/caps/ during and after hours, on weekends and holidays, or through its counselors physically located in the Purdue University Student Health Center (PUSH) during business hours.

Nondiscrimination

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit www.purdue.edu/report-hate to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.

Typical topics for discussion (some may or may not be covered based on time constraints)

1) **Introductory cell biology and biophysics**
2) **Bioimpedance**
    a. **The cell as an electrical circuit**
    b. **Dielectrics**
    c. **Tissue Electrical Properties**
    d. **Excitable tissues**
    e. **Electrodes**
3) **Pulsed power for electroporation and nsPEFs.**

4) **Basics of electroporation**
    a. **Electroporation**
    b. **Transmembrane voltage**
    c. **Smoluchowski Equation**
    d. **Nanosecond pulsed electric fields (nsPEFs)**
    e. **Picosecond pulsed electric fields**
5) **Mechanisms of electroporation**
    a. **In lipids**
    b. **In cells**
    c. **In tissues**
6) **Applications of electroporation**
    a. **Electrochemotherapy**
    b. **Nanoblation**
    c. **Irreversible electroporation**
    d. **Electrical shock**
    e. **Neurons and TASERs**
    f. **Microorganism inactivation**
    g. **Plants/agriculture/bioenergy**
7) **Plasma Medicine/Biology**
    a. **Systems**
    b. **Applications – agriculture, food treatment, wound care.**
    c. **Mechanisms**
    d. **Modeling**
8) **Lasers**
    a. **Optoporation**
    b. **Novel laser systems**

This syllabus is subject to change.