PHY 108
Life as you may have never seen before: a physics perspective

Instructor: Muhammad Sabieh Anwar
Year: 2021-2022
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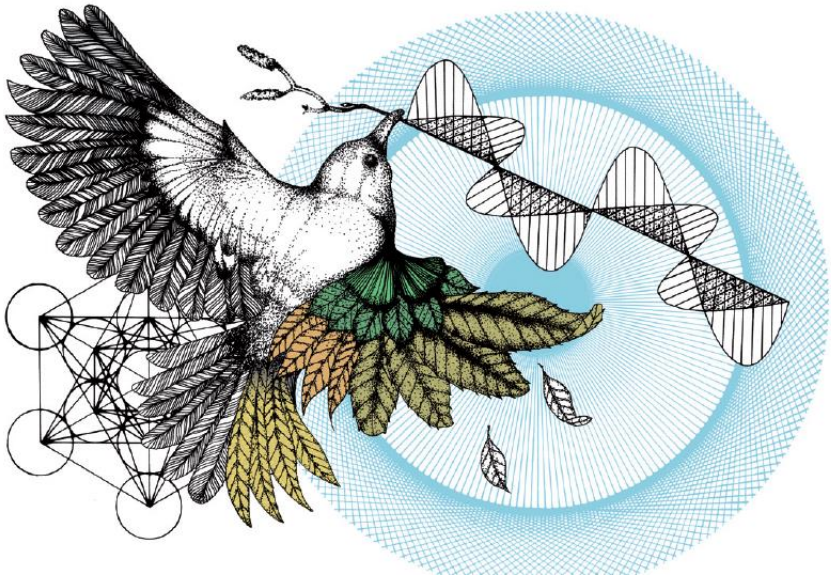
Semester: Spring
Office Hours:
Category: Undergrad
Course Code: PHY 108
Course Title: Life as you may have never seen before: a physics perspective
Credit hours: 1

Website: https://physlab.org/

Lecture format: One 75 minutes lectures per week.

For Harassment policy and honor code, see the last sections of this outline.

Course Description:



This synthesis course uses concepts in university-level physics to explain life phenomena. The course is divided into three major modules. The first module employs mechanics of static objects, fluids and thermodynamics to describe the human circulatory system. The second module covers nerve conduction and various electrical signals propagating in the animal body which are explained by a thorough understanding of basic concepts in electricity and magnetism. The final module touches upon sensory mechanisms and explores how concepts in sound, electromagnetic waves and quantum mechanics can be used to adequately explain

interesting biological processes, some of which are important for our sustenance as a species. There will be emphasis on activities and exploratory learning, evidenced by a self-paced project that student teams will undertake.

Pre-requisites:

PHY 101 Mechanics and a grade of at least B

Co-requisite with PHY 104 (modern physics) or students who have already taken PHY 104

Text books:

Physics of Life by R.P. McCall

For further reading references, see the *tentative course schedule and topics* given below.

Grading scheme:

- Homeworks and computational assignments: 40% (will include optional face-to-face discussion and cross examination of the submitted homeworks)
- Project 30% (will include an in-person presentation and a written report)
- Final Exam 30%
- Grading will be absolute.
- The instructor has the liberty of varying these grade assignments by 10%.

Tentative Course Schedule & Topics:

Weeks	**Topic**	**Some Particular Physics Ideas**
1-4	**My heart lies in physics:** understanding the circulatory system as a mechanical pump and distribution network with graded variations in pressure, flow rates, resistance to flow; thermodynamics of the heart; the Frank-Starling mechanism for cardiac control Activities: a) students will observe, in real time, the oscillometric method of measuring blood pressures; b) students will simulate the cardiac control	Pressure, work-energy principle, continuity, Bernoulli equation, turbulent flow, heat engine, PV diagram, first and second laws of thermodynamics, the Carnot cycle, coupled differential equations and their numerical simulations.

	mechanism in Matlab or Python	
References and reading material: • M. Uehara, K.K. Sakano and S.A. Bertolotti, American Journal of Physics 76, 566 (2008). • M. Uehara and K.K. Sakano, American Journal of Physics 71, 338 (2003).		
5-7	**The spark of life:** models for nerve impulses, the cell membrane as a capacitor, understanding the electrocardiogram (ECG), biomagnetism Activities: students will build or analyze an electronic neuronal simulator	Coupled differential equations, RLC circuits, electrical currents, Ohm's law, electric field, relation between electric field and potential, Kirchoff's current laws, Gauss's law, Biot-Savart law
References and reading material: • J.D. Sitt, F. Campetella and J. Aliaga, American Journal of Physics 78, 1297 (2010). • G.H. Rutherford *et. al*, American Journal of Physics 88, 918 (2020).		
8	**Project synopsis presentations**	
9-13	**Sensorial physics:** models for seeing, sniffing, hearing, color and vision, how do we smell, how do migratory birds move, quantum biology and a model for photosynthesis	The physics of color, the electromagnetic spectrum, wavefunctions and superpositions, phonons, quantum mechanical tunneling, spins inside a magnetic field, singlets and triplets, Schrodinger equation.
14	**Some unfinished business (a general purpose lecture):** complex systems, mathematics and biology, nonlinear phenomena, statistical mechanics for drug and vaccine design	
15	**Final exam and project presentations**	

Harassment Policy Harassment of any kind is unacceptable, whether it be sexual harassment, online harassment, bullying, coercion, stalking, verbal or physical abuse of any kind. Harassment is a very broad term; it includes both direct and indirect behaviour, it may be physical or psychological in nature, it may be perpetrated online or offline, on campus and off campus. It may be one offense, or it may comprise of several incidents which together amount to sexual harassment. It may include overt requests for sexual favours but can also constitute verbal or written communication of a loaded nature. Further details of what may constitute harassment may be found in the LUMS Sexual Harassment Policy, which is available as part of the university code of conduct. LUMS has a Sexual Harassment Policy and a Sexual Harassment Inquiry Committee (SHIC). Any member of the LUMS community can file a formal or informal complaint with the SHIC. If you are unsure about the process of filing a complaint, wish to discuss your options or have any questions, concerns, or complaints, please write to the Office of Accessibility and Inclusion (OAI, oai@lums.edu.pk) and SHIC (shic@lums.edu.pk) — both of them exist to help and support you and they will do their best to assist you in whatever way they can. To file a complaint, please write to harassment@lums.edu.pk.

Honor Code This course and all our interactions are based on the premise that students and I (Sabieh Anwar) will not resort to any means of taking unfair advantage of one another. I will not penalize any student unfairly and will not unduly advantage another. I will stick to norms of decency and mutual respect to my students. Similarly, students will also stick to an honor code---they will not cheat or help others cheat or plagiarize. I will not actively go out looking for plagiarism or cheating. However, if something comes to my notice, I will immediately refer this case to the School's Disciplinary committee for subsequent attention. I will not invigilate exams. I expect students to make their conscience their invigilator. Grading in this course will be absolute.