IB 434 - Physical Principles in Biology (3 credits)
Course Syllabus

Course Description: Examines the interaction between biological processes and the fundamental laws of mechanics. Covers general topics, such as structural analyses of anatomy, kinematics of movement, the behavior of organisms in fluids, and the importance of scaling, as well as specific topics, such as bird flight, fluid flow in cardio-vascular systems, and high speed predation. Lab culminates in student-designed, group projects to collect novel biomechanical data to answer questions about the organism of the students' choice.

SLO: 1) Analyze how mechanical principles influence biological form and evolution across vertebrates, invertebrates and plants. 2) Use critical thinking skills and quantitative reasoning to solve biomechanical problems. 3) Apply biomechanical models to natural phenomena. 4) Use the process of scientific inquiry to perform original research.

Prerequisites: IB 202 or consent of instructor. Physics 101 is recommended.

Requirements met: IB major, upper level lab course.

Professor: Dr. Philip Anderson
Office Location: Vivarium 202A, Office Hours: Varies by semester
Email: andersps@illinois.edu

Lecture: Natural History building, Rm 4074. MF, 2:00-2:50pm

Lab: Natural History Building, Rm 4074. W, 2:00-4:50pm

Textbook:
Pennycuick 1988. Conversion factors. University of Chicago Press (Required)

Vogel 2016. Comparative Biomechanics: Life's Physical World. Princeton University Press (Recommended)

Journal Articles: Readings from the primary literature for lectures and discussions and tutorials for the labs will be made available to students online.

Class Format

Lectures: Every Monday (and select Fridays) will be a one-hour lecture session. During the first 7-9 weeks of the semester, these lectures will focus on fundamental principles in biomechanics and functional morphology. Examples include lectures on the material properties of biological tissues, fluid flow both around organisms, and the mechanical significance of scaling in biology. The purpose of these lectures is to lay a foundation for understanding how animals function in a physical world. Examples used in lecture will be drawn from vertebrates, invertebrates, plants and microbes. For the latter 5-7 weeks, lectures will focus on more complex mechanical problems drawing upon the knowledge gained from fundamentals. These could include terrestrial locomotion, flight

mechanics in birds and insects and flow through circulatory systems. The specific topics covered will be partly determined by class interests.

Discussions: Most Fridays will be one-hour discussion sessions based on the primary literature. The purpose of these sessions is to give the students exposure to a range of topics in biomechanics and functional morphology and particularly how the fundamental principles they are learning in lecture can be applied to broader biological questions. For the first half of the semester, these topics will be chosen by the instructor to help reinforce the lecture material. During the latter half of the semester, each project group (see below) will be responsible for leading one such discussion on a manuscript or topic of their choosing, likely related to their specific project. This will give the students opportunities to help each other in trouble-shooting and developing their projects.

Problem Sets: On three specific Friday sessions, students will work in small groups on problem sets designed to help reinforce the concepts from lectures in lieu of discussion. These problems sets will include both basic word problems involving materials from lecture, interpretive questions based on graphical data, and larger exercises involving primary data that will be provided to the student. Work will be done in groups, although each student will be expected to write-up their own answers.

Labs: During the first eight weeks of the course, the 3-hour lab sessions on Wednesdays will involve directed laboratory practicals designed to give the students hands-on experience with experimental techniques. The purpose of these labs is two-fold: 1) to further reinforce the course material through experiential learning and 2) to give the students an introduction to techniques they may wish to utilize for their projects. Three lab sessions will result in brief (3 page) lab write-ups to be graded.

Project: The ultimate goal of the course will be group-based projects designed and executed by the students during the second half of the semester. These projects should be accomplishable with the resources available to the class, including materials testing devices, high-speed videography, computer simulations, and other equipment. The projects will be question-based, aiming to address specific hypotheses and accumulate novel data on a system of interest. Each student will write a scientific manuscript of the results at the end of the course and all students will participate in short, group oral presentations to the class.

Grading:

Project paper	20%
Project presentation	10%
Project milestones	20%
Lab reports	15%
Problem sets	15%
Participation	20%

Course Grading Philosophy

1) I do not 'curve' individual assignments. Instead, I will assign grade cut off points based on the distribution of student point totals at the end of the semester.

2) I use the standard 90, 80, 70, 60% scores as starting cutoff points for A, B, C, and D grades, respectively. Depending on the distribution of points at the end of the semester I **may** drop the cut off points slightly (e.g., 88% might become the A cut off) but **I will not raise** the cut-offs.

Course Website: We will be using Moodle as our course website. As an enrolled student, you will have access to the course from your Moodle dashboard. It is also accessible here: https://learn.illinois.edu/course/view.php?id=31080. If you do not have access, contact your TA immediately.

What you will find on Moodle:

- The syllabi for lecture and lab
- Updates from the instructors and TAs.
- Resources, lecture notes and handouts.
- Course gradebook

Course Calendar (Fall 2018)

Week	Day	Topic	Due
1	Mon 8/27	Lecture: Introduction to Biomechanics	
	Wed 8/29	Lab: Experimental Techniques	
	Fri 8/31	Lecture: Materials	
2	Mon 9/3	No Class	
	Wed 9/5	Lab: Materials	
	Fri 9/7	Lecture: Structures	
3	Mon 9/10	Lecture: Failure	
	Wed 9/12	Lab: Materials II	
	Fri 9/14	Discussion: Endoskeletons vs. Exoskeletons	
4	Mon 9/17	Lecture: Scale 1, 2/3rd Law	
	Wed 9/19	Lab: Bending/Buckling/Failure	Lab Write-up
	Fri 9/21	Problem Set 1	
5	Mon 9/24	Lecture: Movement	
	Wed 9/26	Lab: Kinematics	Problem Set 1
	Fri 9/28	Discussion: Could T-Rex Run?	
6	Mon 10/1	Lecture: Life in Fluids	
	Wed 10/3	Lab: Visualizing Flow	Lab write-up
	Fri 10/5	Problem Set 2	
7	Mon 10/8	Lecture: Moving through Fluids	
	Wed 10/10	Lab: Hydrodynamics/Project Planning	Problem set 2
	Fri 10/12	Discussion: TBD	Project idea
8	Mon 10/15	Lecture: Scale 2, Reynolds Number	
	Wed 10/17	Lab: Living in a low Re world	Lab write-up
	Fri 10/19	Problem Set 3	
9	Mon 10/22	Lecture: Energy, Engines and Springs	Project Plan

	Wed 10/24	Lab: Group Project Work	Problem Set 3
	Fri 10/26	Discussion: Biomechanics and Diversity	
10	Mon 10/29	Lecture: TBD*	
	Wed 10/31	Lab: Group Project Work	
	Fri 11/2	Discussion: Student Led	
11	Mon 11/5	Lecture: TBD*	
	Wed 11/7	Lab: Group Project Work	
	Fri 11/9	Discussion: Student Led	
12	Mon 11/12	Lecture: TBD*	
	Wed 11/14	Lab: Group Project Work	Project methods
	Fri 11/16	Discussion: Student Led	
13	Mon 11/19	Thanksgiving	
	Wed 11/21	Thanksgiving	
	Fri 11/23	Thanksgiving	
14	Mon 11/26	Lecture: TBD*	
	Wed 11/28	Lab: Group Project Work	
	Fri 11/30	Discussion: Student Led	
15	Mon 12/3	Lecture: TBD*	
	Wed 12/5	Lab: Group Project Work	
	Fri 12/7	Discussion: Student Led	
16	Mon 12/10	Lecture: Biomechanics in Society	
	Wed 12/12	Group presentations	Project Write-up

*Lectures in the second half of the course will vary based on student interest.

COURSE POLICIES

General:

This course will follow all policies in the *Student Code*.
http://www.admin.uiuc.edu/policy/code/index.html

Attendance: Attendance is mandatory for all lectures, discussions and labs unless prior approval is obtained from the instructor. Make a note of the dates now. The only excuse for missing lecture or lab is personal illness or tragedy in your immediate family. Notify Dr. Anderson before lecture or lab if you have a problem. Travel, weddings, jobs, other courses, etc., must be planned around the lecture and laboratory. If you have any questions regarding these policies, please see Dr. Anderson.

Late work: Lab reports and problem sets turned in late without prior approval of the instructor will be docked 10% of the overall grade for each week that passes after the deadline. Effectively, any assignment turned in late within one week of the deadline will be docked 10% (maximum possible credit is 90%). If the assignment is turned in one week after the deadline (e.g. the following Friday after a Friday deadline) or anytime the following week it will be docked 20%, third week 30% and so on.

Final project: As there are no written exams for this course, there is no formal policy for make-up exams. The written report for the final project is under a stricter version of the guidelines for late work described above (10% per two days late). The final group presentations will be done during the final week of classes; attendance is mandatory without prior approval from the instructor.

Accommodations:
If you require special accommodations, please tell me at once. All accommodations will follow the procedures as stated in Article 1-110 of the *Student Code* (http://www.admin.uiuc.edu/policy/code/article_1/a1_1-110.html).

Academic Integrity/Plagiarism:
This course will follow Article 1 Part 4 (1-401 through 1-406) of the *Student Code* (http://www.admin.uiuc.edu/policy/code/article_1/a1_1-402.html). This rule defines infractions of academic integrity, which include but are not limited to cheating, fabrication, and plagiarism. To learn about possible penalties for such a violation, see http:admin.uiuc.edu/policy/code/article_1/a1_1-403.html. You are responsible for being knowledgeable about what the infractions are for not following these guidelines.

Disabilities and Religious Observances: Please contact your instructors or TAs during the first week of classes to make requests for disability accommodations or observation of religious holidays.

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TTY), or e-mail a message to disability@illinois.edu

To obtain waivers for student athlete (cheerleader, marching band, etc.) activities, submit your documentation in person during the first week of class.

Emergency response recommendations

The Department of Homeland Security and the University of Illinois at Urbana-Champaign Office of Campus Emergency Planning recommend the following three responses to any emergency on campus: **RUN > HIDE > FIGHT**

ONLY FOLLOW THESE ACTIONS IF SAFE TO DO SO. When in doubt, follow your instincts—you are your own best advocate!

RUN

Action taken to leave an area for personal safety.

- Take the time now to learn the different ways to leave your building **BEFORE** there is an emergency.
- Evacuations are mandatory for fire alarms and when directed by authorities. **No exceptions!**
- Evacuate immediately. Pull manual fire alarm to prompt a response for others to evacuate.
- Take critical personal items only (keys, purse, and outerwear) and close doors behind you.
- Assist those who need help, but carefully consider whether you may put yourself at risk.
- Look for **EXIT** signs indicating potential egress/escape routes.
- If you are not able to evacuate, go to an Area of Rescue Assistance.
- Evacuate to Evacuation Assembly Area and remain until additional instructions are given.
- Alert authorities to those who may need assistance.
- Do not re-enter building until informed by emergency response personnel that it is safe to return.

ACTIVE THREAT:

- If it is safe to do so run out of the building. Get as far away as possible. Do not go to the Evacuation Assembly Area.

HIDE

Action taken to seek immediate shelter indoors when emergency conditions do not warrant or allow evacuation, such as for severe weather.

- Take the time now to learn the different ways to seek shelter within your building **BEFORE** there is an emergency.
- If you are outside, proceed to the nearest protective building.
- If sheltering-in-place due to severe weather, proceed to the identified Storm Refuge Area or to the lowest, most interior area of the building away from windows or hazardous equipment or materials.

ACTIVE THREAT:

- Lock or barricade your area.
- Get to a place where the threat cannot see you.
- Place cell phones on **silent**.
- Do not make any noise.
- Do not come out until you receive an Illini-Alert advising you it is safe.

FIGHT

Action taken as a last resort to increase your odds for survival.

ACTIVE THREAT:

- If you cannot run away safely or cannot hide, **be prepared to fight with anything available to increase your odds for survival.**