

This syllabus is a general representation of the course as previously offered and is subject to change.

BIOL 438 – Zoological Physics

General Course Syllabus (as of May 2019)

About the Course:

Course Description: Animal systems viewed from a physicist's perspective. Topics include sensory systems, energy budgets, locomotion, internal flows, physical advantages of grouping.

Course Format: Lecture

Credits: 3

Prerequisites: One of PHYS 101, PHYS 107, PHYS 117, PHYS 153, PHYS 157, SCIE 001. (BIOL 325 is recommended.)

Equivalents: PHYS 438 (1994S)

Course Learning Objectives:

By the end of this course, students will be able to:

- Produce mathematical models of various features of animal physiology and use these models to understand the physical and biological constraints that operate on animals.
- Apply basic physical principles to understand how animals function in their environments.

Textbooks and Additional Resources:

Required Textbook: *Zoological Physics, by Boye Ahlborn*. Note: an electronic copy of this book is available for free for UBC students from the UBC library web site. Students must be using a UBC IP address or VPN to access it.

Course Website: www.phas.ubc.ca/~oser/p438/

Grading Scheme:

Assessment	Weight
Homework	30%
Midterm	15%
Poster Project	15%
Final Exam	40%

Schedule of Topics:

Topics covered: Quantitative analysis of zoological systems; biological applications of thermodynamics, mechanics, and fluids; physics of animal body design and locomotion; wave phenomena; optical and acoustical applications to biology; electromagnetic senses of animals

A tentative lecture schedule follows. It may be adjusted as the course proceeds.

Lecture #	Topics Covered
1	Introduction; Life and entropy; energy and metabolic rates
2	Allometric relationships; dimensional analysis; units
3	Energy and work; forces and muscles; mechanical efficiency
4	Power vs. efficiency tradeoffs; heat transfer; radiation, convection, conduction
5	Temperature range of life; maintaining body temperature; thermal properties of the ocean
6	Forces in equilibrium; how muscles generate forces; energetics of muscles
7	Hydrostatic forces: pressure, buoyancy, surface tension. Elastic forces; friction
8	Stress, strain, and materials properties. Allometry revisited
9	Mechanical principles of body design
10	Fluid dynamics. Bernoulli's Law. Lift & drag.
11	Moving nutrients across barriers: diffusion, cell size, pipe flow
12	Turbulence; blood pressure; the circulatory system
13	Oxygen requirements; capillaries; how lungs work; heart and breathing rates
14	Basic kinematics; linear and rotational motion; moments of inertia; methods of acceleration
15	Terminal velocity; jet propulsion in animals; Energetics of movement; elastic materials in the body; resonance frequencies and motion
16	Poster project discussion
17	Periodic motion and resonance
18	Swimming
19	Flying
	NO CLASS -- midterm break
	NO CLASS -- midterm break
	NO CLASS -- midterm break
20	Walking and running
	MIDTERM EXAM
21	Basic properties of waves: amplitude, phase, velocity
22	Basic properties of waves: interference, diffraction, reflection, refraction, Huygen's principle
23	Light; thermal spectra; pinhole cameras; refraction
24	How lenses work; diffraction; the human eye

25	Strange, freaky animal eyes
26	Interference effects in animals: anti-reflective coatings; why cat eyes shine in the dark; iridescence
27	What is sound? Speed, intensity, and impedance. Measuring volume. Beat phenomena
28	Impedance matching and sound transmission. The mammalian ear. Frequency/sensitivity range of hearing
29	Vibrations in strings. Vibrations in air columns. How animal voices work.
30	Echolocation; Doppler shifts
31	Electric fields, currents, resistivity. How nerves work. Sensing electric fields
32	Producing electric fields
33	Biological use of magnetic phenomena
	POSTER SESSION I: WRITTEN REPORTS DUE FOR ALL TEAMS
	POSTER SESSION II

Course Policies

Homework: There will be approximately biweekly homework assignments. Students are welcome to discuss problems informally with their classmates. However, students must complete the assignment themselves, and if they hand in obviously copied homework, they should expect a mark of zero on that assignment, and a penalty to their final course grade. The instructor reserves the right to refer incidents to UBC for an academic misconduct investigation as well. Assignments are due in class on their due date. Late assignments are not accepted, but the instructor will throw out the lowest homework score for one assignment.

Poster Project: Working in teams of three or four, students will prepare a "research poster" illustrating a particular example of zoological physics. This will include reviewing the relevant research literature and doing their own calculation/mathematical modelling of the topic they choose. At the end of term there will be two poster sessions at which students will show their poster as well as view their classmates' efforts. More details of the poster project will be given during the term.

Missed exams: There will be one in-class midterm exam. If students miss the exam with a legitimate excuse (proof of illness, family emergency, etc), they should see the instructor to discuss make-up options.

Religious holidays: Students are entitled to request an alternate test date if a scheduled test date falls on one of their holy days. If students think this may apply to them, they should contact the instructor as soon as possible to make an alternate arrangement. It is advised that students do not put this off until the last minute--- students must give *at least* two week's notice.

University Policies:

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence.

UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom.

UBC provides appropriate accommodation for students with disabilities and for religious, spiritual and cultural observances.

UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions.

Details of the policies and how to access support are available on [the UBC Senate website](#).