ILLINOIS MATHEMATICS AND SCIENCE ACADEMY®

igniting and nurturing creative, ethical scientific minds that advance the human condition

Comprehensive Course Syllabus

Course Title - Biophysics

Course Description:

Biophysics will draw upon concepts from SI Physics, SI Biology, and SI Chemistry to study energy/power/efficiency, diffusion, thermal transfer, and fluid flow. These concepts will be developed in the context of animal function, adaptation, and evolution. In addition to homework, laboratory reports, and exams, students will also report on topics they have researched.

INSTRUCTOR(S):

- Name: Dr. Mark Carlson
- Office Number: B104A, Office hours: by appointment
- Telephone number: 630 907 5975
- Email address: mcarlson@imsa.edu,

Meeting Days, Time and Room: B/D mods 1-2 (8:10-9:50) in B145

Text(s) / Materials:
Textbook: Introduction to Biological Physics for the Health and Life Sciences – Franklin et al.
Supplemental readings will also be posted for materials on reserve in the IRC or linked to Moodle.
Materials: Laptop Computer, Calculator, Notebook, Pencils

Essential Content:

The curriculum addresses all 5 broad Science Learning Standards: inquiry, energy & matter, force & motion, cellular structure and function, and evolution and genetics. While all 8 subcategories from Inquiry will be touched upon, emphasis will be on A2, 3, 5, and 6; forging connections, complex thought, reasoning, and models. Modeling biological features as simpler physical systems requires complex reasoning that must be cultivated via group class work and assignments. Four out of the 5 (B2-5) areas in energy and matter will be featured prominently. When looking at the efficiency of metabolism and the kinetic theory of diffusion and heat transfer; bonding, conservation, equilibrium, as well as work and heat will be treated in depth. In regard to force and motion, 2 of the 3 (C2-3) areas will be reviewed in terms of analyzing motion based upon Newton's Laws, The fourth standard, cellular structure and function, is also addressed, primarily through examination of metabolism (D2) and sub-cellular features (D1). The last area, evolution, is constantly referred to throughout the course when examining the traits (E3) which represent animal adaptations.

SSLs and Outcomes:

IA. Students expected to demonstrate automaticity in skills, concepts, and processes that enable complex thought by

- completing homework **FA**
- completing assigned reading **NA**
- completing in-class exercises **IA**

IB. Students expected to construct questions which further understanding, forge connections and deepen meaning by

- participation in classroom discussions **IA**
- thoughtful consideration of extension questions in homework, labs, and tests **FA**

IC. Students expected to precisely observe phenomena and accurately record findings through

- data collection and observations. **FA**
- analysis of data generated from experiments and videos. **FA**

ID. Students expected to evaluate the soundness and relevance of information and reasoning by

- drawing conclusions from laboratory data and simulations. **FA**
- evaluating the reasonableness of answers. **FA**
- explaining, analyzing and developing models to explain phenomena. **FA**

IIA. Students identify unexamined personal assumptions and misconceptions that impede and skew inquiry

- by reconciling data/observations and preconceptions. **FA**

IIIA. Students use appropriate technologies as extensions of the mind through

- use of calculators for problem solving. **NA**
- use laptop computers to access internet **NA**
- use of standard office software and scientific software **IA/FA**
- use of laboratory equipment for data collection and analysis. **NA/IA**

IIIB. Students recognize, pursue, and explain substantive connections within and among areas of knowledge by

- applying previous concepts from SI-Physics, SI-Chemistry, & SI-Biology to address issues in biophysics **IA/FA**

IIIC. Students recreate beautiful conceptions that give coherence to structures of thought by

- applying concepts to real world examples **FA**

IVA. Students construct and support judgments based on evidence by

- drawing appropriate conclusions in lab work and tests supported by data/analysis. **FA**

IVB. Students write and speak with power, economy, and elegance by

- communicating effectively in written work, oral presentations, and group discussions **IA/FA**

IVC. Students identify and characterize composing elements of systems by

- modeling a complex organism with simplified elements **IA/FA**

VB. In order for students to make reasoned decisions which reflect ethical standards, and act in accordance with those decisions, students

- are made aware of what plagiarism is, its ethical implications, and repercussions of plagiarizing. **IA**
- are made aware of the scientific and ethical significance of accurately representing data (vs. not skewing data to fit expectations). **IA**

Instructional Design and Approach:

The progression of topics within a unit and of the units themselves is by design. Each unit will be introduced through an engineering issue that confronts an organism. The issue arises as a consequence of the previous unit and motivates the study of the current topic. Within each unit, first, relevant concepts from SI will be reviewed and extended. New concepts will then be introduced and connected with a hands-on demonstrations or activities. Finally, we will examine how organisms manipulate physical parameters to their advantage. Students will work individually and collaboratively on assignments, discussions, and projects. Each unit will have a capstone activity that is problem centered and driven in part by student questions appropriate to the unit, Eg. power vs. efficiency debate, diffusion presentations, animal temperature regulation posters, etc. Activities will be varied and will include calculation, bench work, discussions, and computer simulations.

Student Expectations:
Students are expected to follow the attendance and tardy policies of the Academy. They are expected to come to class prepared to participate and collaborate with others solve problems and perform laboratory experiments. Outside of class, students are expected to complete assigned readings, complete problem sets, follow-up on class discussions, prepare presentations, and write lab reports. Students are encouraged to collaborate, but the work turned in for credit must be their own. Refer to the student handbook for more details.

Academic Responsibility

A. Students are expected to arrive in class on time. Unexcused tardies in excess of 5 minutes will be treated as unexcused absences. Please refer to the Attendance and Tardiness Procedures section of the handbook.
B. Students are expected to bring proper materials to class including.
    1. Calculator
    2. Laptop computer
    3. Pen/pencil and paper
C. Students are expected to submit all assigned work by the designated time. Late work will receive penalties as determined by the instructor.
D. When in class, students are expected to be alert, to listen intently, and to actively participate in class activities scheduled for the day.
E. Students are expected to use their laptop computers to support class instruction.
F. Students are expected to leave class with notes from the lesson of the day.
G. Students should get help early. Options include:
    1. Appointment with instructor
    2. Email instructor

Laboratory Policies

Violating safety rules may result in penalties or students may not receive credit for that activity/experiment. Collaboration among partners is encouraged. However, each partner is expected to submit his/her own work when an individual report is required.

Ethics

Honesty is a key component of scientific work, whether on the forefront of scientific research or in an IMSA laboratory. The practices (both good and bad) that are learned in an IMSA lab greatly influence your education. Consequently any violation of the honesty policy is considered a serious offense.

Examples of Violations:

1. Falsification of data; fabricating or changing data in your notebook or formal reports. NOTE: It often happens that, in performing an experiment, "obviously" bad data is obtained. It is NOT acceptable to simply discard the suspect data; however, you should include a short note or explanation of why you are disregarding the data.
2. Plagiarism: representing another's work as your own; submitting written reports with sections directly or indirectly quoted from another source without referencing that source.

Working Together, where to draw the line:

In experiments done with partners, it is expected that you will share data and observations. It is expected that you will always discuss the experiment and exchange ideas with your partner(s), other students, your instructors, etc. However, unless specifically told otherwise, each report is an **individual report**. By signing your name to it, you testify that the ideas, calculations, results, discussions and conclusions are yours alone, except as referenced. Copying, borrowing, lending or sharing of the words and work of or with another, (directly or by paraphrasing) is plagiarism. Simply put, all intellectual exchanges **before** writing the report are acceptable. Unreferenced use of another's written material or joint production of a written report is not acceptable, unless you are specifically told to write a group report. Consequences of violating these rules are explained in the student/parent handbook. These guidelines also apply to the completion of homework assignments (problem sets) as well.

Assessment Practices, Procedures, and Processes:

The course is built upon 4, approximately 4-week units. Each unit has formative assignments in the form of homework and lab reports. Each unit has an exam that is summative for the unit and formative with respect to the cumulative final. Exam format includes conceptual multiple choice questions, numerical free response problems, and application essays. The essay portion of the exam is significant and is usually done in-class although on occasion it might be take-home. A typical essay requires the student to identify an organism feature, state the physical need it is addressing, articulate the physical principle involved, provide the relevant equation, and describe how the variables are optimized to benefit the organism.

Grading scale:

A- 90.0-92.4%	A 92.5-100%	
B- 80.0-82.4%	B 82.5-87.4%	B+ 87.5-89.9%
C- 70.0-72.4%	C 72.5-77.4%	C+ 77.5-79.9%
	D 0.0-69.9%	

Grade Distribution:

Exams and quizzes	- 50%
Cumulative Final	- 20%
Homework	- 15%
Lab reports & projects	- 15%

Sequence of Topics and Activities

Energy Unit

Review: PE, KE, work, stoichiometry, chemical equilibria
Introduce: efficiency, power, bond enthalpies, Gibbs Free Energy
Connections: energy-storing adaptations, convergent evolution

Diffusion Unit

Review: kinematics, normal distribution, standard deviation
Introduce: equipartition theorem, diffusion equation, Fick's Law, action potentials
Connections: cell size, capillaries, respiration, neurons

Thermal Transfer Unit

Review: temperature, insulation
Introduce: conduction, convection, radiation, Maxwell Boltzmann Distribution
Connections: thermal regulation, multi-layer conduction, warm-blooded animals

Fluid Flow Unit

Review: circulatory anatomy
Introduce: series & parallel, continuity, pressure/flow relationship
Connections: fluid flow networks, flow regulation, shock & hypertension

Review for Final