**BIOL 551 – COMPARATIVE BIOMECHANICS – SPRING 2020**

***Time:*** 12:30-1:45 T, Th

***Location:*** Room 1373, Genome Sciences Building

***Instructor:*** Dr. Bradley Dickerson (Office: 2157 Wilson Hall; email: bdicker@email.unc.edu )

***Text:*** Vogel, S. (2013) *Comparative Biomechanics: Life’s Physical World.* 2nd Ed. Princeton, Princeton University Press.

Jan 9 Introduction to course and to biomechanics

Jan 14 Gases, buoyancy, pressure and solubility, liquids, cohesion

Jan 16 Surface tension, capillarity, Laplace’s Law, bubbles, pores, air-water interface

Jan 21 Solids vs. fluids, viscosity, the Reynolds number, no-slip condition, streamlines

Jan 23 Vortices, Strouhal number, flow forces, Bernoulli’s principle, pitot tubes

Jan 28 Venturi tubes, pressure and drag, the drag coefficient

Jan 30 Drag on motile organisms, drag reduction, laminar boundary layers, turbulent boundary layers

Feb 4 Diffusion vs convection, Peclet number, flow through pipes

Feb 6 Flow between plates, parabolic pipe flow, turbulent pipe flow, flow through apertures, pumps

Feb 11 Circulatory systems, diffusion, convection, Murray’s Law, vessels, pumping, open versus closed

Feb 13 Life at low Reynolds numbers, reversibility of flow, Stokes’ Law, locomotion, feeding, appendages

Feb 18 Animal flight, lift, Flettner rotors, airfoils, lift coefficient

Feb 20 Gliding, scaling of fliers, soaring

Feb 25 Thrust, advance ratios, flapping flight

Feb 27 Swimming, drag versus lift-based thrust, surface waves, hull speed, wave energy, running on water

Mar 3 Solid mechanics, tensile materials, pliant materials, rigid materials, stress, strain, stiffness, strength

Mar 5 True stress, true strain, strain energy storage, resilience, work of fracture, shear modulus, Poisson’s Ratio

--Spring Break--

Mar 17 Non-Hookean materials, material properties, fracture mechanics, critical crack length, composite materials

Mar 19 Biological materials, viscoelasticity, creep, stress-relaxation, dynamic testing

Mar 24 Structures, flexural stiffness, beams, cantilevers, cross-sectional shape, columns, buckling

Mar 26 Torsion, torsional stiffness, domes, shells, scaling, trusses, braced frameworks, spicules

Mar 31 Multi-bar linkages, joints, degrees of freedom, hydrostatic skeletons, crossed-fiber arrays, hydraulic linkages

Apr 2 Muscular hydrostats, adhesion

Apr 7 Adhesion, supportive systems, muscle

Apr 9 Muscle, muscle performance, velocity, force

Apr 13 Muscle performance, work loops, muscle diversity

Apr 16 Mechanical advantage, pennation, muscle gearing

Apr 21 Jumping, terrestrial locomotion, gaits, energetics, legless locomotion, safety factors

Apr 23 Loose ends

May 1 FINAL EXAM, High Noon

***Textbook:***

We are using a relatively recently revised textbook for the course [Vogel, S. (2013) *Comparative Biomechanics: Life’s Physical World.* 2nd Ed. Princeton, Princeton University Press.] that covers a wide range of topics in the field of comparative biomechanics. The author, the late Dr. Steven Vogel, was renowned for his writing. Indeed, he received a prize for scientific writing for one of his books. Back when I first took biomechanics as an undergraduate, I used the first edition of this book and have found it quite helpful throughout my academic career. In fact, I still keep my first edition copy in my office. I am confident that you will enjoy the book. If you are accustomed to not doing the reading and relying on lecture only, I encourage you to break the habit! The book is well-written enough that you will be missing out on some key insights and examples. This will allow you to get more out of each lecture and since The lectures are fast-paced, so completing the readings in advance will help you to keep up with the material. The lectures are designed to follow the sequence in the book, an approach that has pleased the majority of past students. If you feel, however, that there is too much overlap and would like some additional reading, please see me and I will make some recommendations of especially good books and scientific papers.

The first three chapters of the book are background and are likely to be review for most of you. I encourage you to read them as they provide a useful reference and background for topics in the later chapters. We will cover the topics in detail starting with Chapter 4.

***Lectures:***

I will begin promptly at 12:30 and would appreciate it if you could be on time. I realize that many of you will need to walk to the other side of campus for your next lecture so will try to end lecture on time. As an aid to following my lectures I will provide an outline at the beginning of each class and will also recommend the reading for the next class meeting.

***Exams and Grading:***

I wish to take advantage of the fact that this is a smaller class and to give you more attention and feedback than I can in a larger one. I will use problem sets rather than exams throughout the semester. I believe that exams are often imperfect; one studies the material in advance of an exam and while taking it you may discover that there are topics you did not understand as well as you hoped. By the time the exam is handed back, we are on to new topics and you often do not have time to go back and master the material. The problem sets allow you to spend time going over the material and working through the difficulties. I have found that students learn much more this way. This is especially true for topics with a physics focus; equations have a dismaying tendency to go in one ear and out the other unless you use and manipulate them. The majority of the students regard the use of problem sets quite positively by the end of the semester. There is, I admit, frequently skepticism at the beginning and a conversion at the end! I could not attempt this in a larger class since the grading is extremely time-consuming. Every few weeks I will hand out a problem set, which will be due **one week** later. I will give you advance warning. Although you are welcome to use your textbook and notes, I ask that you not consult with one another about the problems. In the past I have had some problems with students submitting the problems after the due date. The prompt students felt it was unfair that the tardy students had more time so requested that I adopt some sort of penalty. I understand their point so have instituted a penalty of **10% drop** in grade each day if they are submitted late. I am required to give a final exam, which will be based on the material of the entire course and will count for 25% of the grade. The problem sets will count for the remainder.

***Honor Code:***

The Chancellor requires that you read the attached statement of the Honor Code. This course has had relatively few problems in the past, in part I suspect because you are most likely here because the topic seems interesting, as opposed to simply meeting a graduation requirement. I want to mention nevertheless that because there are often a number of ways to solve the problems on the problem sets, it is immediately obvious if students have worked together. So please do avoid consulting with one another on the problem sets.

**BIOL 551 – COMPARATIVE BIOMECHANICS – HONOR CODE STATEMENT**

The following statement is paraphrased from *The Instrument of Student Judicial Governance*:

Academic dishonesty in any form is unacceptable, because any breach in academic integrity, however small, strikes destructively at the University's life and work. The Honor Code and the Campus Code, embodying the ideals of academic honesty, integrity, and responsible citizenship, have for over 100 years governed the performance of all academic work and student conduct at the University. Acceptance by a student of enrollment in the University presupposes a commitment to the principles embodied in these codes and a respect for this most significant University tradition. Your participation in this course comes with my expectation that your work will be completed in full observance of the Honor Code. If you have any questions about your responsibility or my responsibility as a faculty member under the Honor Code and as the instructor in this course, please bring them to me, or consult with someone in either the Office of the Student Attorney General or the Office of the Dean of Students.

The following sections explain what I expect from you in terms of meeting these standards:

* **Pledge:** *The Instrument of Student Judicial Governance* requires that you sign a pledge on all written work. (“On my honor, I have neither given nor received unauthorized aid on this assignment”). This includes all problem sets and exams. I will not grade a problem set unless you have signed the pledge.
* **Problem Sets:** You are welcome to use your books and your class notes when preparing the problem sets. You are **not** allowed to discuss the problem sets with other classmates or to ask anyone for assistance (including me!). Please be aware that there are frequently several different ways to solve a given problem and it is immediately obvious to me when students have worked together.
* **Exam:** The final exam is to be taken without the assistance of books, notes or other people. You may, however, study with your classmates.