BIOL 551 – COMPARATIVE BIOMECHANICS – FALL 2015

**Time:** 11:00-12:15 T, Th
**Location:** Room 1374, Genome Sciences Building
**Instructor:** Dr. William M. Kier (Office: 313 Wilson Hall; email: billkier@bio.unc.edu)

August 18  Introduction to course and to biomechanics
August 20  Gases, buoyancy, pressure and solubility, liquids, cohesion
August 25  Surface tension, capillarity, Laplace’s Law, bubbles, pores, air-water interface
August 27  Solids vs. fluids, viscosity, the Reynolds number, no-slip condition, streamlines
September 1  Vortices, Strouhal number, flow forces, Bernoulli’s principle, pitot tubes
September 3  Venturi tubes, pressure and drag, the drag coefficient
September 8  Drag on motile organisms, drag reduction, laminar boundary layers, turbulent boundary layers
September 10  Diffusion vs convection, Peclet number, flow through pipes
September 15  Flow between plates, parabolic pipe flow, turbulent pipe flow, flow through apertures, pumps
September 17  Circulatory systems, diffusion, convection, Murray’s Law, vessels, pumping, open versus closed
September 22  Life at low Reynolds numbers, reversibility of flow, Stokes’ Law, locomotion, feeding, appendages
September 24  Animal flight, lift, Flettner rotors, airfoils, lift coefficient
September 29  Gliding, scaling of fliers, soaring
October 1  Thrust, advance ratios, flapping flight
October 6  Swimming, drag versus lift-based thrust, surface waves, hull speed, wave energy, running on water
October 8  Solid mechanics, tensile materials, pliant materials, rigid materials, stress, strain, stiffness, strength
October 13  True stress, true strain, strain energy storage, resilience, work of fracture, shear modulus, Poisson’s Ratio
October 15  Fall Break
October 20  Non-Hookian materials, material properties, fracture mechanics, critical crack length, composite materials
October 22  Biological materials, viscoelasticity, creep, stress-relaxation, dynamic testing
October 27  Structures, flexural stiffness, beams, cantilevers, cross-sectional shape, columns, buckling
October 29  Torsion, torsional stiffness, domes, shells, scaling, trusses, braced frameworks, spicules
November 3  Multibar linkages, joints, degrees of freedom, hydrostatic skeletons, crossed-fiber arrays, hydraulic linkages
November 5  Muscular hydrostats, adhesion
November 10  Adhesion, supportive systems, muscle
November 12  Muscle, muscle performance, velocity, force
November 17  Muscle performance, work loops, muscle diversity
November 19  Mechanical advantage, pennation, muscle gearing
November 24  Jumping, terrestrial locomotion, gaits, energetics
November 26  Thanksgiving
December 1  Legless locomotion, safety factors, tuning of structures, biomimetics
December 10  FINAL EXAM, High Noon
Textbook:

We have a 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, Dr. Steven Vogel, James B. Duke Professor Emeritus, Duke University, is a colleague and old friend who is renowned for his writing and indeed received a prize for scientific writing for one of his recent books. I was delighted when Steve published the first edition of the book because I had struggled to find texts of the appropriate breadth and depth. With the publication of the first edition, I completely revised the course and have made some additional revisions to reflect changes in the second edition. 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 so well written that you will be missing out. I have found that students do much better in the course if they complete the readings in advance of the lecture. This will allow you to get more out of each lecture and since the pace of the lectures is fast it will help you to keep up with the material. When I revised the course I designed the lectures to follow the sequence in the book, an approach that pleases the majority of students. But if you feel 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 on the topics we cover in lecture.

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 11:00 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 could in a larger class. 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. But by the time the exam is handed back, we are on to new topics and you often do not have time to 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 and 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 try to use and manipulate them. The majority of the students regard them quite positively by the end of the semester; there is frequently scepticism 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 provide 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. I have had relatively few problems in this course 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.
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.