# KINE 500: Advanced Biomechanics

California State University San Marcos Fall 2016 CRN: 42451


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| **Instructor:** | Devin Jindrich | **Email:** | djindrich@csusm.edu |
| **Office:** | UH 310 | **Phone:** | 760-750-7334 |
| **Office Hours:** | By appointment | | 4 Credit Hours |


"From there to here, from here to there, funny things are everywhere." – Dr. Seuss

## COURSE DESCRIPTION

Explores how the physical and mechanical properties of organisms and their environment affect biological tissues, structures, and behavior. Demonstrates how principles and techniques from fields such as physics, engineering, functional morphology and physiology can be used to understand motor performance, capability and failure. Emphasis will be placed on investigating causes of injury and disease, and understanding or designing techniques to overcome motor impairments. The laboratory component involves using current biomechanical measurement and analysis techniques to perform detailed investigation of specific movements.

## CONTENT LEARNING OUTCOMES

Our overall learning objective is to understand how humans and other organisms interact with the physical environment to make effective movements. We think about how organisms are *structured*, and what the *requirements* for making movements are. Movement is constrained by tissue properties (of bone, tendon, etc.), the physics of segmented systems, to the physical properties of muscles involved in most movements. In KINE 500, we try to understand how organisms achieve high performance and avoid damage given the constraints of the internal and external mechanical environments.

Completing this course involves being able to:

1) Understand the mechanical principles that govern the behavior of biological materials in the physical environment
2) Apply concepts and techniques from physics and engineering to basic and applied biomechanics questions
3) Understand the causes of mechanical injuries and synthesize potential strategies to restore mechanical function
4) Evaluate the effectiveness of biomechanical interventions to improve and restore movement.

## SKILL LEARNING OUTCOMES

Another objective of this course is to become more skilled in scientific reasoning and quantitative measurement, analysis, and evaluation. Completing the course involves being able to:

1. Apply general principles and knowledge of biomechanics to specific movement contexts
2. Effectively read, understand, analyze, and evaluate scientific literature
3. Generate biomechanical hypotheses that are novel, important, reasonable and testable
4. Use data acquisition tools (of Force and Motion) to quantitatively measure human movement
5. Use functional programming (MATLAB) to analyze biomechanical data
6. Use data and basic statistics to evaluate biomechanical hypotheses
7. Identify sources of uncertainty and use them to weigh evidence
8. Construct arguments to defend hypotheses, experimental methods, and data-based conclusions
9. Report scientific findings using clear, well-organized written and oral presentation

## KINESIOLOGY PROGRAM STUDENT LEARNING OUTCOMES

This course is designed to contribute to all Kinesiology student learning outcomes (KSLOs):

1. Describe fundamental principles of Kinesiology, including anatomy and physiology, teaching movement related skills, physiological response to exercise, and the mechanics and control of movement.
2. Apply Kinesiology related skills to real-world problems through empirical research, internships, field experience, and/or service learning.
3. Evaluate movement science questions through 1) the performance of health, fitness, and movement assessment, 2) the acquisition, analysis, and interpretation of original data, and 3) the appraisal and application of information from current research literature.
4. Utilize oral and written communication that meets appropriate professional and scientific standards in Kinesiology.
5. Model behavior consistent with that of a Kinesiology professional, including 1) advocacy for a healthy, active lifestyle, 2) adherence to professional ethics, 3) service to others, 4) shared responsibility and successful collaboration with peers, and 5) pursuit of learning beyond CSUSM.

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## GRADUATE COURSE

KINE 500 is a graduate course. What does that mean? Graduate courses in the Department of Kinesiology typically involve more in-depth investigation of topics and require greater use of critical thinking and analytical skills than is normally expected at the undergraduate level. Graduate courses typically:

1. Involve understanding concepts, issues, problems, and/or techniques that are current topics of scholarly investigation.
2. Require understanding of both theoretical principles and applied content.
3. Require analysis of primary research and/or professional literature.
4. Require students to identify sources of uncertainty in measurement and interpretation.
5. Require students to consider alternative hypotheses and complex, multi-factorial systems.
6. Provide opportunities to apply research findings to solving relevant problems.
7. Encourage independent and creative thinking and problem-solving.
8. Require students to weigh uncertainty, evaluate competing hypotheses, and make determinations of the most likely/reasonable explanations, predictions or strategies for action.
9. Require written and oral communication at a professional level.

## LECTURES AND QUIZZES

The primary content for this course will be available through a textbook, online lectures, in-class lectures and reading (primary literature). Online lectures will augment the textbook: they contain information to use for in-class activities and discussions, or provide opportunities for review. Each lecture segment will address one or more of the questions, as listed in the schedule below. Quizzes covering the lecture segments will provide practice for answering exam questions.

## TEXTBOOK

**Comparative Biomechanics: Life's Physical World.** Steven Vogel. Princeton: Princeton Univ. Press, 2003. Pp. xii + 582.

## WEBSITE

Lecture notes, handouts, online lectures, quizzes, instructor correspondence, grades, etc. will be available through the course website. If you need help with web access or computer use or have any unique needs, please contact the instructor.

## EMAIL

I always make an effort to respond to emails as promptly and thoroughly as possible. To facilitate prompt responses, it is important for me to be able to easily identify class emails. Consequently, I request that any emails that you send me about the course begin with "KINE500" in the subject line. For example, a subject could read "KINE500: Appointment Request." I cannot guarantee responses to emails that do not have "KINE500:" in the subject. In the case that I am slow to respond to an email, please feel free to simply re-send the message. My inbox gets out of control sometimes, and emails can get lost or mis-filed, and I appreciate the reminder if I have somehow misplaced a message or failed to respond for any other reason.

## SCHEDULES

The schedules and reading assignments contained in this syllabus may be subject to change. It is up to you to make sure that you are aware of all announcements concerning changes in the course outline, readings, assignments, exams, and other matters made during class periods whether or not you are in attendance when announcements are made. Some assignments for each class are listed below. Reading the material before class is likely to lead to more interesting class time and also facilitate studying.

## ATTENDANCE

Regular attendance is essential. Many missed assignments, including quizzes or lab activities, CANNOT be made up, except in the case of university business or approved holiday. Accepting late assignments is not fair to other students for several reasons. For example, it interferes with our ability to discuss assignments during class periods.

## CLASSROOM COURTESY

Please follow these guidelines for common courtesy:

- Respect individual diversity of each person in the class.
- Turn Cell Phones off before class, do not text message.
- Do not listen to a device during class time, including keeping the ear piece in your ear.
- Use computers in class only for class activity. Attempts to multitask (i.e. texting, etc.) will decrease performance

## ACCOMODATIONS FOR DISABILITIES

We will make any reasonable accommodations for limitations due to any disability including learning disabilities. Please arrange an appointment to see me to discuss any needs you might have. All discussions are confidential. Students with disabilities who require academic accommodations must be approved for services by providing appropriate and recent documentation to the Office of Disabled Student Services (DSS). This office is located in Craven Hall 4300 and can be contacted by phone at (760) 750-4905, TDD (760) 750-4909 or by email at: dss@csusm.edu. Students authorized by DSS to receive accommodations should meet with me during my office hours, or in another private setting, in order to ensure your confidentiality. **Note:** Please inform me during the first week of classes about any disability or special needs that you have that may require specific arrangements related to attending the class sessions, carrying out class assignments, or writing papers or examinations.

## COLLABORATIVE WORK

You will work in small groups to complete lab assignments, discuss assignments, and complete some quiz questions (e.g. KSLO 5). However, online quiz answers must be submitted individually. Collaborative work is an opportunity to learn from each other, divide labor on assignments, learn through teaching, meet others in the class and major, become accustomed to team-based work, etc. Therefore, collaborative work is an important part of the class and your grade will reflect your contribution to the success of your groups. Evidence of leadership, effort, organization, congeniality and flexibility will favorably reflect on your performance in the class. However, collaborative work is not meant to include sending emails to the entire class with answers to quizzes or tests, which is considered a violation of the honesty and integrity policies.

## WRITING

The University has an "All-University Writing Requirement" that students write at least 2,500 words for a 3 or more unit course. The University requirement reflects the importance of writing for virtually every field of study and career. Therefore, we will emphasize writing (specifically scientific/technical writing), and assessments for most laboratory work will be written papers.

FORMATTING IS NOT WRITING. You may have been told (repeatedly) to use APA or MLA reference formatting. In my opinion, the emphasis on APA reference formatting comes at great cost to actually learning how to write. I don't care in the slightest how your references are formatted, so long as they are clear and complete (including complete references that I can cross-check). Margins, spacing, reference styles, etc. are matters of appearance and are NOT important for this class.

What IS important is that you write using specific, concise, and clearly-written sentences. MOST important is that you structure your paragraphs and papers using REASONING (deductive and/or inductive): that you lead the reader to specific, clear conclusions using specific, clear evidence. Use APA formatting if you want – I don't care. So long as your papers are well-reasoned, I'm good.

## EXAMS

Exams will assess comprehension of the important concepts presented in the course, and the ability to apply these concepts to novel problems. The assignments and exam dates are scheduled ahead of time for your convenience, therefore plan accordingly. A missed exam or assignment can potentially be excused with a VALID AND WRITTEN EXCUSE FROM A REPUTABLE SOURCE. Otherwise, no points can be given for the exam/assignment. Communication or other forms of cheating during exams will result in a failing grade for the course and possible referral to the university for disciplinary action.
**NOTE:** Exams in lecture portion of the class will also cover content from pre-lab lectures/readings.

## HOW TO ANSWER QUIZ AND EXAM QUESTIONS

What does "scientific reasoning" in the skill learning objectives above mean? Although there is a certain amount of new INFORMATION that will be presented – the primary goal of this course is NOT simply to remember the information. The goal is NOT to learn a series of definitions, or names of structures or processes, or people or dates. A certain amount of terminology is necessary, but simply memorizing terminology will not result in high performance. KINE 500 is not intended to be one where someone with a photographic memory could simply breeze through (sorry if this is you ;-). A primary objective of the quizzes, exams, and laboratory reports is to **understand principles, apply knowledge and evaluate hypotheses**. Application and evaluation involve applying concepts or facts from the course to come to a conclusion about some novel statement or situation.

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## TIME EXPECTATIONS

Completing a college courses is traditionally expected to involve 2-3 hours per week per credit hour of effort outside the course. Therefore, a reasonable expectation of this course would be that it will entail about 8-12 hours of effort outside of class time during the normal semester. The effort required each week may vary, but on average the time might be expected to break down as shown in the table to the right.

| ACTIVITY | TIME INVESTED |
|---|---|
| Reviewing lectures/reading | 3-4 hours |
| Completing quizzes | 1 hour |
| Lab assignments | 4-6 hours |
| Studying for exams | 1 hour |

Organization is half the battle. In my experience, there is a high correlation between organization and success. Be sure not to fall behind on lectures, quizzes, and studying. Having a weekly schedule, and adding class time into your schedule for each course (as you might for your work and other activities) can greatly improve performance and reduce stress. Completing an assignment early takes as much time as completing it at the last minute, but usually results in higher grades (particularly if you get feedback).

## CLASS PERIODS

Most class periods will consist of

1) Lectures
2) In-class activities demonstrating course concepts
3) Answering questions about course material
4) Reviewing quizzes
5) Laboratory application

If there are other things that you read about, hear about, know about, etc. that are relevant to the course, please do bring these up and discuss them! Class discussions are always welcome so long as they are focused and include everyone.

## OFFICE HOURS

I encourage you to make use of office hours, or make appointments to come talk to me if you have questions or concerns. I have observed dramatic improvements in grades through one-on-one interaction. I also appreciate any and all feedback about the structure of the course, the material, ideas for making things better or clearer, etc. Feedback provided will not factor into grading decisions.

My office is in UH 310. If you arrive for an appointment and my door is closed, please knock. I keep the door open for all meetings with students, without exception.

## EXPECTATIONS OF THE INSTRUCTOR

What is the instructor's job? To transfer information from their brain to the students'? To sort and rank students through grades? I would argue that these are not possible or desirable, respectively.

Ideally, instructors have several responsibilities:

1) Instructors identify information and concepts that are most important for understanding. Based on knowledge and experience, instructors select the most relevant topics for study and reflection from the vast amounts of information available.
2) Instructors design activities that guide students through the process of discovery and learning. Instructors provide encouragement and constructive criticism, identify important questions and encourage students to become actively engaged in inquiry.
3) Instructors provide examples of the thinking process of their disciplines. Instructors demonstrate the creative process that leads to new ideas (e.g. testable hypotheses), and show examples of using evaluation and judgment to come to conclusions.
4) Instructors must somehow assess student learning in the course (i.e. grading). Instructors must determine the level of understanding required, design assessments for students to demonstrate understanding, and clearly communicate the instructor's expectations to students.
5) Instructors are responsible for maintaining academic standards and integrity. Instructors are responsible for ensuring that college-level coursework in each class is appropriate for the field, the class level, contributes to Department and University learning objectives, and has a long-term impact on students. Personally, I consider it an ethical imperative not to sell students short based on assumptions or potential misperceptions. I assume that ALL students are capable of HIGH QUALITY work on par with students anywhere. It is the instructor's job to try to find ways to achieve high performance for each individual, and help to motivate the students to put in the time and effort necessary for excellence.

Finally, instructors have an added responsibility. Instructors have a responsibility not to spell everything out for the students. This responsibility stems from the fact that guidance, clarity, and communication may seem conducive to **knowledge** learning (although guidance is not necessarily the most effective strategy), excessive guidance can actually be detrimental for **skill** learning. Improving writing, or analysis, or evaluation skills requires attempting to perform assignments without complete guidance – in the presence of perceived uncertainty both in the desired outcome and the best path to reach the outcome. Skill learning depends on making mistakes: having expectations that are not completely structured and allow for errors, trial and correction, and, yes, even the potential for frustration.

**SOME SUGGESTIONS FOR SUCCESS**

There is a lot that can be gained from KINE 500 (in my own humble opinion ;-) Getting the most out of it is easiest if you are organized, not overly stressed out, and have enough time to reflect on some of the topics that we cover. Some suggestions:

1) Keep up-to-date on the lecture material and even get ahead a little. Just like setting your clocks faster by a few minutes can sometimes help getting places on time… if you set personal deadlines ahead of class deadlines, things will seem much easier.
2) Keep a record of areas that are confusing and ask questions.
3) Try to understand, not simply memorize, course material. Understanding means putting information in frameworks of other things that are already known, and thinking about connections among different course topics. Compare and contrast different topics from the course, etc.
4) Please Please Please don't be satisfied with poor performance! If a quiz or exam score does not reflect the effort made to learn the material, then come to office hours, consult peers, take action to improve! I am confident that everyone is capable of getting a top grade. Don't sell yourself short and settle for less!
5) Please give me feedback about aspects of the course that you are not satisfied with. I can't change everything this semester, but some things I can!

**CLASSROOM HONESTY AND INTEGRITY**

Honesty and integrity are a reflection of your character. Therefore, cheating is considered a serious offense. Students will be expected to adhere to standards of academic honesty and integrity, as outlined in the Student Academic Honesty Policy. All written work and oral presentation assignments must be original work. All ideas/material that are derived from other sources must have appropriate references to the original sources. Any quoted material should give credit to the source and be punctuated with quotation marks.

Students are responsible for honest completion of their work including examinations. There will be no tolerance for infractions. If you believe there has been an infraction by someone in the class, please bring it to the instructor's attention. The instructor reserves the right to discipline any student for academic dishonesty, in accordance with the general rules and regulations of the university.

Disciplinary action may include the lowering of grades and/or the assignment of a failing grade for an exam, assignment, or the class as a whole. Incidents of Academic Dishonesty will be reported to the Dean of Students. Sanctions at the University level may include suspension or expulsion from the University.

Students are expected to conduct themselves in a manner appropriate for class and comply with the rules of student conduct. The rules of student conduct are included in the California Code of Regulations, Title 5, and beginning at Section 41301. A student who violates university policies or regulations is subject to disciplinary action, which can result in a warning, reprimand, probation, suspension, or expulsion. The Chancellor of the California State University specifies procedures under which the university may take disciplinary action against a student. These procedures are on file in the Office of the Dean of Students, Craven Hall, Room 5306.

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## LABORATORY GUIDELINES

Laboratories will consist of designing hypothesis-based studies to test questions in biomechanics. Frequently, lab activities will involve (1) a short review of the problems and relevant literature highlighting a gap in our knowledge of a particular problem; (2) generating both GENERAL and MEASURABLE hypotheses (3) designing an experiment that will allow for controlled, quantitative measurements; (4) collecting data using laboratory equipment and techniques; (5) analyzing the collected data to test the measurable hypothesis; and (6) discussion of the implications of the outcomes of the experiment on the general hypothesis, potential limitations that could have affected the results, and potential alternative interpretations. Specific guidelines for effective scientific writing and presentation will be an important component of the laboratory.

**Requirements for Lab**

- Attendance and participation are mandatory, except for health reasons at the discretion of the professor**.** The instructor will take Roll at the beginning of lab. Missing a lab will result in losing at least 4 points. Being late for lab will also result in forfeiture of participation points.
- No food allowed in the laboratory.
- Proper attire, including closed-toed shoes is required.
- Laboratory write-ups are due on the dates specified.
- You must bring a thumb drive or equivalent to store your personal data for analysis.
- Leaving without completion of the in-class portion of your lab will be considered an absence.

**Recommendations for Lab**

- Computers will be available for data analysis. There will be up to 20 students in the lab section. You may choose to bring your own laptop computer for data analysis.
- On some lab days, we will only have one data collection system and 20 students. You will have down time. A productive student might choose to use this down time to work on their homework assignments and/or discuss them with other students.

**Lab Assignments**

Laboratory assignments will be made available for download from Cougar Courses. Assignments will contain three parts: **preparation**, **lab activities**, and **assignments**. You will be expected to arrive prepared by completing pre-laboratory assignments (online lectures, readings, etc.). During the lab activity section, you must complete the lab activity before you leave for the day. You may choose to work on the analysis section of your laboratory assignment at home or in the computer lab if you prefer. However, it is recommended that you make use of your instructor's assistance in completing the lab requirements. Your lab assignment will be due as indicated (typically the next time that your lab section meets). *Laboratory papers that are not typed will not be accepted.* Many lab sections involve acquiring or reinforcing specific **skills**. Although you will work in groups, it is important to make sure that you are competent with each required skill, because each skill will be required for future labs.

**PAPER SUBMISSION**

Laboratory handouts will be collected at the end of each laboratory period. Written papers will be submitted through **Turnitin**. Please include your name within any document that you submit.

**PLAGIARISM**

"'Plagiarism" can be defined as using another's words, ideas, materials or work without properly acknowledging and documenting the source. Students are responsible for knowing the rules governing the use of another's work or materials and for acknowledging and documenting the source appropriately.

**GRADING**.

I don't particularly like grading – but it has to be done. Ideally, grades are valid assessments of learning. Unfortunately, grades often assess only some aspects of learning and can be influenced by lots of other confounding factors ☹. My honest suggestion is to focus on really understanding the material well and don't worry about the grade – it will take care of itself (for the best). Also, it is usually best to keep focused on what YOU have control over. You have control over how you organize your time and how much time you allow for this course, how focused and dedicated you are when studying, how effectively you use your group time, the

effort you put into connecting new information to things you already know, etc. You have control over your strategy for getting correct answers on each individual test question. However, you typically DO NOT have control even over simple things like how many test questions you get correct, and therefore your overall exam score (unless you know the correct answers to all questions, then you could potentially get some wrong to achieve a desired score ;-). You DO NOT have control over your final grade. Final grades are the worry of one person – the instructor (and believe me I worry about grades and try to make sure that they are fair and reflect learning).

In general, thinking about your grade is not really a good use of time apart from using your current score to change the way you approach the class. Whether half way through the term you have the grade you want or not, I would argue that in either case, what you DO should be the same: try to learn the material the most effectively you can using the time that you have. Therefore, I would advise against spending time thinking about the grade (which you do NOT have control over) and focusing on learning (which you DO have control over).

Grades will be assigned according to points earned during the course. The course is NOT curved. If everyone gets an "A," then I'll be ecstatic.

| *GRADING* | *Points* | *Percent of final grade* |
|---|---|---|
| **Class Assignments** | **50** | **10%** |
| **Lab attendance and write-ups** | **150** | **30%** |
| **Exam 1** | **40** | **8%** |
| **Exam 2** | **60** | **12%** |
| **Final Exam** | **100** | **20%** |
| **Project Presentation and Paper** | **100** | **20%** |
| **Total** | **500** | **100%** |

| *POINTS* | *PERCENTAGE* | *LETTER GRADE* |
|---|---|---|
| **500-465** | **100%-93.0%** | **A** |
| **464-450** | **92.9%-90.0%** | **A-** |
| **449-440** | **89.9%-88.0%** | **B+** |
| **439-415** | **87.9%-83.0%** | **B** |
| **414-400** | **82.9%-80.0%** | **B-** |
| **399-390** | **79.9%-78.0%** | **C+** |
| **389-365** | **77.9%-73.0%** | **C** |
| **364-350** | **72.9%-70.0%** | **C-** |
| **349-340** | **69.9%-68.0%** | **D+** |
| **339-300** | **67.9%-60.0%** | **D** |
| **299-000** | **59.9%-0.00%** | **E** |

## CLASS SCHEDULE

***Subject to change at any time***

**Classes are Thursday 4:00-9:50 PM, University Hall 240**

| *Date* | *Topic* | *Questions* | *Reading* |
|---|---|---|---|
| **01 SEPTEMBER SECTION 1** | **Introduction to the course**<br>**Learning objectives**<br>**Background concepts**<br>**Physics Review** | Do we understand the basic physical principles necessary for biomechanics? | Vogel: 3-17<br>McMahon (1975) |
| **LAB 1** | **Scientific Method** | How do we design experiments? | Platt(1964), Fudge(2014) |
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| **08 SEPTEMBER SECTION 2** | **Scaling** | How does body size affect mechanical constraints?<br>How does size affect mechanical loading? | **Vogel** Ch. 2,3,4: pp. 19-70 |
| **LAB 2** | **Quantities and Units**<br>**Dimensional Analysis** | How can dimensionless numbers potentially be useful? | |
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| **15 SEPTEMBER SECTION 3** | **Presentations and Discussion: Scaling**<br>**Scientific Reasoning** | What are some of the potential mechanisms and implications of scaling? | **Individual Papers**: Scaling |
| **LAB 3** | **Discussion: Scientific Method**<br>**Scientific Writing** | How do we communicate scientific reasoning, analysis, and conclusions? | Brand (2001, 2008) |
| | | | |
| **22 SEPTEMBER** | | **EXAM 1 (Sections 1-3, Labs 1-3)** | |
| **22 SEPTEMBER SECTION 4** | **Material Properties of Solids**<br>**Stress, strain, Biological Materials** | What does it mean for a material to be "strong"? | **Vogel** Ch. 15 pp. 301-323 |
| **LAB 4** | **Principles of functional programming**<br>**Programming in MATLAB** | How do we use a 4GL scripting language like MATLAB? | **Take-home programming assignment** |
| | | | |
| **29 SEPTEMBER SECTION 4** | **Exam 1 Review**<br>**Energy, Cracking, Tendons, bones**<br>**Viscoelastic Materials** | How do materials fail?<br>How does compliance change material properties? | **Vogel** Ch. 16 pp. 325-351<br>**Vogel** Ch. 17 pp. 353-364 |
| **LAB 4** | **Presentations and Discussion: Bone**<br>**Principles of functional programming**<br>**Programming in MATLAB** | How do we use a 4GL scripting language like MATLAB? | **Individual Papers:** Bone<br>**Take-home programming assignment** |
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| **06 OCTOBER SECTION 5** | **Simple Structures**<br>**Stiffness, Shape** | How does shape affect the mechanical behavior of structures? | **Vogel** Ch. 18: pp. 365-388 |
| **LAB 4** | **Principles of functional programming**<br>**Programming in MATLAB** | How do we use MATLAB to analyze data? | **Take-home programming assignment** |
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| **13 OCTOBER SECTION 6** | **Beam theory**<br>**Biological Structures**<br>**Mechanisms and Hydrostatic Structures**<br>**Lever Systems** | What are the advantages and trade-offs associated with biological mechanisms?<br>How can we design mechanisms to achieve desired behavior?<br>How can we design structures to achieve desired mechanical properties? | **Vogel** Ch. 19,20: pp. 389-422 |

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| | | Can we calculate joint loading? Does knowing joint loading allow us to predict injury? | |
| LAB 5 | **Presentation and Discussion: Structures**<br>**Force Measurement** | How do we measure forces? How do we calibrate and validate force measurements? | **Individual Papers:** Structures<br>Collins et al. (2009)<br>Biewener and Full (1992)<br>Munro et al. (1987) |
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| **20 OCTOBER**<br>**SECTION 7** | **Muscle** | How do the physiological and architectural properties of muscle enable and constrain movement?<br>How do the physiological and architectural properties of muscle enable and constrain movement? | **Vogel** Ch. 22,23: pp. 443-476 |
| LAB 5 | **Force Measurement/Analysis** | How do we condition and analyze force recordings? | Blickhan and Full (1992)<br>Pezzack et al. (1977) |
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| **27 OCTOBER**<br>**SECTION 7** | **Muscle**<br>**Biomechanics of Locomotion on Land** | How can mechanical design help humans and other animals move on land? | **Papers:** Dickinson et al. (2000) |
| LAB 5 | **Force Measurement** | How do we condition and analyze force recordings? | **LAB**: Force measurement |
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| **20 OCTOBER** | | **EXAM 2 (cumulative to Section 7, Lab 5)** | |
| **03 NOVEMBER**<br>**SECTION 8** | **Exam 2 Review**<br>**Biomechanics of Locomotion on Land** | What kinds of loading are joints exposed to? How can we measure joint loading? | **Vogel** Ch. 24: pp. 477-493 |
| LAB 6 | **Presentation and Discussion: Muscle**<br>**Kinematic Data Acquisition** | How do we measure movement in a modern lab? | **Individual Papers**: Muscle<br>Biewener and Full (1992) |
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| **10 NOVEMBER**<br>**SECTION 9** | **Dynamical Systems Theory and Stability** | What are different ways of measuring stability during posture and movement? | **Reading:** Full et al. (2002),<br>Biewener and Daley (2007) |
| LAB 6 | **Kinematic Data Analysis** | How do we analyze and process movement data? | Vint and Hinrichs (1996)<br>Wood (1982)<br>Yu et al. (1999) |
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| **17 NOVEMBER** | **Fluid Basics** | How do fluids work? | **Vogel** Ch. 5: pp. 93-116 |
| LAB 6 | **Presentation and Discussion: Stability**<br>**Kinematic Data Analysis** | How do we measure movement in a modern lab? | McGowan et al. (2005) |
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| **24 NOVEMBER** | **Moving Fluids**<br>**Fluid Forces: Drag and Lift** | What causes drag and lift forces on structures?<br>How do fluid dynamics affect circulation and respiration? | **Vogel** Ch. 6: pp. 117-138<br>**Vogel** Ch. 7: pp. 139-164 |
| LAB 6 | **Kinematic Data Analysis** | How do we analyze and process movement data? | **LAB**: Kinematics |
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| **01 DECEMBER** | **Swimming and Flying** | How do organisms swim and fly? | **Vogel** Ch. 12: pp. 245-265<br>**Papers:** TBD |
| LAB 7 | **Presentation and Discussion: Fluids**<br>**Statistics Review**<br>**Practical and Resampling Statistics** | Bootstrapping statistics | **Individual Papers:** Fluids<br>**Reading:** Efron and Tibshirani (1991) |
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| **08 DECEMBER** | **Swimming and Flying** | What is the difference between steady-state and unsteady fluid | **Vogel** Ch. 13: pp. 267-284 |

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| | **Course Review and Summary** | dynamics?<br>How do different biomechanical systems interact? | |
| **LAB 7** | **Practical and Resampling Statistics** | Bootstrapping statistics | |
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| **15 DECEMBER** | **FINAL EXAM (cumulative)**<br>**FINAL PRESENTATIONS** | | **FINAL PAPER DUE** |

"Stay Hungry. Stay Foolish" – Stewart Brand