**Brief Overview of Course Objectives:**

There are two streams of major learning objectives. The first is to give students practice at the higher-level thinking skills of problem solving, creative thinking, and synthetic thinking (conceptual combination). The second is to educate students about how mechanical laws relate to the structure of organisms, emphasizing the biomechanics of movement over solids and through fluids.

**Workload: Total student workload for Biology 3665 is approximately 15 hours per week.**

By successfully completing BIOL 3665 students earn one credit of lecture and two credits of lab. University of Utah [**policy 6-303**](https://regulations.utah.edu/academics/6-100.php)aims to keep student workload per credit hour comparable across courses and course-offering units as follows:

For one semester lecture credit the university expects students to spend at least one hour in class and at least another two hours outside of class each week, or the equivalent combination. Since biology 3665 counts as one lecture credit, expected workload for the lecture credit is at least 3 hours each week over the course of the semester. Please note these are averages over the course of the semester. When a topic is introduced there are more lectures and less lab work. The aim is to provide the background information up front, so that students gain a deeper understanding of the subject and gain more from the work done for the labs.

Many of these lectures are available on YouTube, which allows for the playback speed to be varied (value added - you can hear your instructor sound like Mickey Mouse). For your convenience, estimates of most lecture times (normal speed) are given in the schedule. Toward the end of the course there are fewer lectures, but you are expected to invest this time into developing and testing your hypothesis, research proposal, data collection and analysis, and writing up your results.

For one laboratory semester credit hour, the university expects students to spend at least 2-3 hours each week in class and approximately the same amount time outside of class, or the equivalent combination, over the course of the semester. Since biology 3665 counts as two laboratory credits, the workload is at least 8 - 12 hours each week for the two lab credits.

**Tips:**

The online nature of this course gives students the flexibility to work ahead of the weekly schedule, allowing students to plan for heavy work-load periods from other classes, for example at midterms, or other factors in their life. I am glad I can provide this much needed flexibility; however, I do not want students to fall behind and so there is a penalty for turning in assignments late. The grade is reduced 10% for each day it is late.

I believe that we learn from our mistakes, especially if given the chance to correct them, so I allow all work to be corrected and resubmitted. I will grade the corrected assignment and average the two grades for the final score for the assignment. These corrected assignments must be submitted within two weeks of receiving the graded assignment. The bottom line is that it is generally to students' advantage to turn in work on time, and if the grade is not satisfactory, correct the work and take the average of the two grades.

**Tentative Schedule (subject to change with reasonable notice)**

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| **Date, Lab Type, Place**  **Tentative Schedule (subject to change with reasonable notice)** | **LAB TITLE AND BRIEF DESCRIPTION** | **Lecture Title and Length, links to handouts and instructions** |
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| Jan 11  3:05-5pm  in person  Marriott Library room 1745 | **Understanding and Working with Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) Technology and Data.**  In this lab I will give a course overview, discuss learning objectives, introduce Horos software and CT and MRI technology and data, and check equipment out to you.  We will use Horos to analyze CT data over several labs. Horos is opensource and runs on mac operating system and can be downloaded from this website: [Horos](https://horosproject.org/download-horos/) (https://horosproject.org/download-horos/). If you have a mac or iPad and want to use your own computer, then if you bring it to class I will help you load the software. This software is available on the Marriott Library Mac Lab computers in room 1745. You will be asked to answer a series of questions on these lectures.  Please watch the CT and MRI lectures before coming to class on Jan 11.  You can download a pdf Horos introduction produced by Cornell at this url.  https://www.biotech.cornell.edu/sites/default/files/2020-06/Introduction%20to%20Horos%20and%20Osirix.pdf | [CT Lecture](https://www.youtube.com/watch?v=9SUHgtREWQc&t=3s)  [(26 min)](https://www.youtube.com/watch?v=9SUHgtREWQc&t=3s)  [MRI Lecture](https://www.youtube.com/watch?v=djAxjtN_7VE)  [(26 min)](https://www.youtube.com/watch?v=djAxjtN_7VE)  [Logarithms](https://www.youtube.com/watch?v=VSi0Z04fWj0)  (15 min)  [Linear Models (27min)](https://www.youtube.com/watch?v=7ArmBVF2dCs&t=0s)  Homework available on canvas |
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| Jan 18  online | **Biomechanics of Solids Part I: Computing Area Moment of Inertia (I)**  You will use Horos and a set of data from ostriches of different body size to compute the area moment of inertia (I) at the midshaft of a hindlimb bone, the tibiotarsus, and compare your measurements to published values of I for a growth series of emu.  Watch the online lectures focusing on: (1) the history of the study of solids; (2) stress and strain of solid building materials, such as bone; (3) how size and shape affect these stresses and strains and how animals' bodies respond to these scaling relationships; (4) how to work with data across different sizes.  Required Reading:  Main and Biewener 2007 Skeletal strain patterns and growth in the emu hindlimb during ontogeny. [JEB 210: 2676-2690](https://journals.biologists.com/jeb/article/210/15/2676/16983/Skeletal-strain-patterns-and-growth-in-the-emu). | [Biomechanics I (1hr 16 min)](https://www.youtube.com/watch?v=5k3hkWx_u5k)  [Biomechanics II (25 min)](https://www.youtube.com/watch?v=PWtSl7PY59s)  [Optional/](https://www.youtube.com/watch?v=aQf6Q8t1FQE)  [supplemental](https://www.youtube.com/watch?v=aQf6Q8t1FQE)  (10 min)  [Optional/ supplemental](https://www.youtube.com/watch?v=Bls5KnQOWkY)  (11 min)  Module instructions on canvas |
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| Jan 25  online | **Biomechanics of Solids Part II: Computing Polar Moment of Inertia (J) & Rotational Inertia (RI)**  You will use Horos and a set of data from ostriches of different body size to estimate the polar moment of inertia at the midshaft of the tibiotarsus, and compare your measurements to published values for a growth series of emu. You will compute J along the long axis of the bone and compare to similar data from the human tibia. You will compute rotational inertia of the ostrich hindlimb zeugopod.  Required Reading:  Cristofolini et al. 2013 [Shape and function of the diaphysis of the human tibia](https://www.sciencedirect.com/science/article/pii/S0021929013002200)  Journal of Biomechanics 46(11):1882-1892.  (https://www.sciencedirect.com/science/article/pii/S0021929013002200) | Review relevant lecture (Biomechanics I)  [Optional/](https://www.youtube.com/watch?v=1YTKedLQOa0)  [supplemental Lecture](https://www.youtube.com/watch?v=1YTKedLQOa0)  (10 min)  Module instructions on canvas |
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| Feb 1  online | **Biomechanics of Solids Part III: Polar Moment of Inertia & Rotational Inertia of gharial and alligator skulls.** | Review relevant lecture (Biomechanics II)  Module Instructions on canvas |
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| Feb 8  online | **Biomechanics of Solids Part IV: Scaling of Alligator Humeri**  You will be given a set of data of alligators of different body masses and make measurements using Horos on the humeri. You will then plot these data using excel on arithmetic and logarithmic scales and do regression analyses of these data. | Review relevant lecture  Module instructions |
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| Feb 15  online | **Life in Fluids**  You are asked to watch a series of lectures (total time is about 5 hours 15 min) on basic principles of fluid mechanics and to answer questions based on these lectures. Part I explains why it is important to study fluid dynamics to understand animal form and function and begins a discussion of how to study fluids, including the simple stresses of compression and tension. Part II emphasizes the importance of shear stress in the study of fluids, introduces key terminology and concepts and then discusses some interesting biological examples. Part III focuses on key concepts important to understanding insect flight. Part IV discusses how aquatic animals generate thrust and overcome drag in high and low Reynolds number regimes, and introduces the Navier-Stokes equation, which will be used in the fluid modeling labs. Part V discusses internal flows, such as through a blood vessel. | **Life in Fluids**  [Part I](https://www.youtube.com/watch?v=F7iio76hC8o) (37 min)  [Part II](https://www.youtube.com/watch?v=7Bzew7t22cM)  (1hr 15 min)    [Part III](https://www.youtube.com/watch?v=T3xfsZVBESc) (30 min)  [Part IV](https://www.youtube.com/watch?v=rJl-eB6Sn78)  (1hr 25 min)  [Part V](https://www.youtube.com/watch?v=SXsmgZ9RlCo)  (1hr 26 min)  Homework on canvas |
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| Feb 22  in person  Marriott Library room 1745 | **Computational Fluid Dynamics (CFD) Modeling Part I: Fluid Flow Over a Plate**  You will be given an account on the Center for High Performance Computing (CHPC) and will log into this system to access a software package called Ansys. You will use this software for fluid simulations over a flat plat. | In class lecture |
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| March 1  online | **CFD Modeling Part III:** **Flow Around a Shark**  You will watch online videos and use Ansys to model fluid flow around a shark. | [CFD Lecture II](https://www.youtube.com/watch?v=43lUKyEH9AY)  (41 min) |
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| March 8 | **Spring Break** |  |
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| March 15  online | **CFD Modeling Part II:** **Fluid Flow Through a Blood Vessel**  You will watch online videos and use Ansys to model fluid flow through a blood vessel. | [CFD Lecture III](https://www.youtube.com/watch?v=4St1XOvrlQo)  (1hr 7min) |
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| March 22  online | **Using an Accelerometer**  This week you watch several online videos and then use an accelerometer and integrated \*\*\*\* to select appropriate sampling frequencies for a series of cyclic signals you produce by moving the accelerometer. You will also collect acceleration data on yourselves while hopping and pool these data with data collected by your classmates. | Sampling Frequencies  [Aliasing](https://www.youtube.com/watch?v=FcXZ28BX-xE)  (17 min) |
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| March 29  online | **Formulating a Hypothesis & Devising Methods to Test the Hypothesis**  You will formulate a hypothesis and write a research proposal for testing the hypothesis. These will be submitted for peer review. After reading information on how to provide quality peer review, you will peer review two research proposals.  Required reading: How to give peer review | No Lecture |
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| April 5  online | **Testing Your Hypothesis**  After considering the peer review comments and modifying your research proposal as need be, you will resubmit a revised proposal. You will also collect and submit data that have been requested by your fellow students for their hypotheses. These data are then used by students to test the hypothesis using appropriate statistical methods. Online videos are provided to explain basic concepts of statistics. | No Lecture |
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| April 12  online | **Biomechanical Analyses of Countermovement and Squat Jumps**  You will use the accelerometer to record a countermovement jump and a squat jump. You will then analyze the acceleration data to compute jump height and velocity as well as different phases of the jump. | [Video of countermovement jumps](https://www.youtube.com/watch?v=qN3apht8zRs)  (2 min) |
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| April 19  3-5pm  Marriott Library  room 1745 | **Equipment check in** |  |
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**Lab and Assignment due dates (subject to change with reasonable notice)**

There is a weekly reflection journal (WRJ) due each Friday by 11:59 pm. Most assignments are due by Friday night with the exceptions of assignments related to your hypothesis testing (lab 11).

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| **HW #** | **DUE**  **Date** | **Assignment Description** |
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| 1 | Friday Jan 13 | Introductory Video  Weekly Reflection Journal (WRJ)  CT MRI questions |
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| 2 | Friday Jan 20 | Area Moment of Inertia Tibiotarsus Lab Write-up  WRJ |
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| 3 | Friday Jan 27 | Polar Moment of Inertia and Rotational Inertia Tibiotarsus Lab Write-up  WRJ |
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| 4 | Friday Feb 3 | Polar Moment of Inertia and Rotational Inertia Gharial and Alligator Skulls Lab Write-up  WRJ |
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| 5 | Friday Feb 10 | Alligator Humeri Morphometrics & Scaling Models  WRJ |
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| 6 | Friday Feb 17 | Questions regarding Life in Fluids  WRJ |
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| 7 | Friday Feb 24 | Fluid Model External Flow Over a Flat Plate Lab Write-up  WRJ |
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| 8 | Friday March 3 | Fluid Model of External Flow Over a Shark Lab Write-up  WRJ |
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| 9 | Friday March 17 | Fluid model of Internal Flow through a blood vessel Lab Write-up  WRJ |
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| 10 | Friday March 24 | Accelerometer data and analysis  WRJ |
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| 11 | Wed March 29 | Hypothesis & Research Proposal |
|  | Friday March 31 | Peer Reviews  WRJ |
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| 12 | Mon April 3 | Revised proposal |
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| 13 | Friday April 7 | All data requested by your peers  WRJ |
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| 14 | Friday April 14 | Research results written as a scientific paper  WRJ |
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| 15 | Friday April 21 | Countermovement and Squat Jump lab write-up  WRJ |

OBS open broadcast