OEB 173 - Comparative Biomechanics

Spring 2022: TuTh, Noon-1:15 PM
Oceanography Seminar Rm: **MCZ 100** (across from MCZ Mailroom: see map)

Professor: Andrew Biewener (AB; biewener@fas.harvard.edu, office: MCZ Room 1)
Teaching Fellow: Zhe He (ZH; zhehe@g.harvard.edu, office: BioLabs 3105)

This course combines an exciting mix of 15 *Lectures* (ranging from 40 to 75 min), 5 *TF guided Discussions* of lecture topics and problem sets (ranging from 30-75 min), 4 *class Seminar discussions* of research papers (75 min each); and 4 biomechanics class *Activities* (75 min – full class period).

Class Schedule:

Date	**Prof**	**Class topic/Activity**	**Assignment due**
Tu Jan 25	AB	**Lect #1:** Introduction to biomechanics: Jumping right in! Terrestrial locomotion & ground reaction forces. **Reading**: Physics review sheets (if needed)	
Th Jan 27	AB	**Lect #2:** & Terrestrial locomotion & CoM mechanics. Inverse dynamics & joint moments. Legged robotics & remote sensing of field locomotion. **Reading**: *Biewener & Patek - Ch 4*	
Tu Feb 1	AB	**Lect #3:** Muscle: force production and movement. Motor Control of movement. **Reading:** *Schmidt-Nielsen Ch 10 (p 402-425)* (**Problem Set 1** posted)	
Th Feb 3	ZH AB	**ACTIVITY 1: Terrestrial Locomotion: kinematics & force plate recordings** (MCZ)	
Tu Feb 8	AB ZH	**Lect #4:** Biological materials and properties: stress, strain, stiffness, & elastic energy. (45 min) **Reading:** Vogel Ch 4 (p 65-67); Ch 15; Ch 16 (p 325-334, 341-351) & *Wainwright Ch 2 (p 6-15)* **Discussion 1:** Lecture topics #1-3, & Problem Set 1 (30 min)	
Th Feb 10	AB ZH	**SEMINAR 1:** (2 Papers Discussion) Terrestrial locomotion & muscle mechanics.	**Problem Set 1**
Tu Feb 15	AB	**Lect #5:** Composite Material design & Fracture **Reading:** Vogel Ch 16	ACTIVITY 1 **Lab Report**

		(**Problem Set 2** posted)	
Th Feb 17	AB	**Lect #6:** Viscoelasticity: Time-dependent properties. **Reading:** Vogel Ch 17; *Wainwright Ch 2 (p 25-39)*	
Tu Feb 22	ZH	**Discussion 2:** Lecture topics #4-6 & Problem set 2	
Th Feb 24	AB ZH	**SEMINAR 2:** (2 Papers Discussion) Biological materials and their functional roles.	**Problem Set 2**
Tu Mar 1	AB ZH	**ACTIVITY 2:** Musculoskeletal dissection (frog, bird, or mammal) ****LOCATION: MCZ 202** (**Problem Set 3** posted)	
Th Mar 3	AB	**Lect #7:** Biological structures: shape, stress distributions; scaling and safety factors. Measuring bone and tendon loading mechanics. **Reading:** Vogel Ch 18; Vogel Ch 25 (p 497-501); *Alexander (1981)*; Further reading: *Currey Ch 10; Biewener Ch 6*	
Tu Mar 8	ZH ZH	**Lect #8:** Plant biomechanics: material properties linked to structural mechanics. (45 min) **Discussion 3:** Lecture topics #7&8, & Problem Set 3 (30 min)	ACTIVITY 2 **Lab Report**
Th Mar 10	AB ZH	**SEMINAR 3:** (2 Papers Discussion) Animal and/or plant mechanics and scaling.	
Mar 12-20		**Spring Recess**	
Tu Mar 22	AB	**Lect #9:** Forces of flow: energy, momentum & Bernoulli's Eq.; pressure, drag & Reynolds number. **Reading:** Vogel – Ch 5, 6 & 7 (**Problem Set 4** posted)	**Problem Set 3**
Th Mar 24	AB	**Lect #10:** Lift: force coefficients, and circulation. Soaring & gliding. **Reading:** Vogel Ch 12 **Poster Topics - Initial Discussion**	
Tu Mar 29	AB ZH	**Lect #11:** Thrust and introduction to flapping flight. (45 min) **Reading:** Vogel Ch 13 **Discussion 4:** Lecture topics #9-11 & Problem Set 4 (30 min)	
Th Mar 31	ZH	**Activity 3:** COMSOL Fluid Mechanics Lab (SEC 1.107, Allston campus)	

Tu Apr 5	AB	**Lect #12:** Flapping (powered) flight continued & unsteady aerodynamic mechanisms.	**Problem Set 4**
Th Apr 7	AB	**Lect #13:** Swimming: aquatic locomotion at high Reynolds numbers. **Reading:** Vogel – Ch 13	
Tu Apr12	AB	**Lect #14:** Locomotion at low Re numbers and at the air:water interface. **Reading:** Vogel Ch 11 (Problem Set 5 posted)	ACTIVITY 3 (**no report:** qualitative feedback on Comsol Lab Activity)
Th Apr 14	ZH	**Discussion 5:** Lecture topics #12-14	
Tu Apr 19	AB ZH	**SEMINAR 4:** (**3 Papers Discussion) Lift & drag; Flight and gliding and air:water interface.	**Poster Topic Due**
Th Apr 21	ZH	**Lect #15:** Fluid transport in plants; circulatory blood flow in animals. **Reading:** Vogel – Ch 14	
Tu Apr 26	AB ZH	**LAST CLASS!** **ACTIVITY 4:** HMNH Animal Exhibit/Biomechanics Interpretation & student presentations	ACTIVITY 4 **Reflective Discussion** **Problem Set 5**
Th Apr 28		**Reading Period**	
TBD	AB ZH	**CFS Laboratory Field Trip, Poster Session**; Lunch or Dinner (Reading period) **11A-4P**	**Poster Presentation**
Th May 5		(Exam period begins)	

TEXTBOOK:

Steven Vogel, *Comparative Biomechanics* Princeton Univ. Press (2013)
(available via Harvard COOP & Amazon.com)

Other source readings:

Biewener = A Biewener & B Full, *Biomechanics: Structures and Systems*. Oxford Univ Press. 1992.
Biewener & Patek = A Biewener & S Patek, *Animal Locomotion, 2nd Ed*. Oxford Univ Press. 2018.
Currey = JD Currey, *Bones: structure and mechanics*. Princeton Univ Press. 2002.
Wainwright = SA Wainwright et al., *Mechanical Design in Organisms*. Princeton Univ Press. 1982.
Schmidt-Nielsen = K. Schmidt-Nielsen, *Animal Physiology: Adaptation and Environment.* Cambridge Univ. Press, 1997.

GRADING:

	Weight
Final Poster	15%
Problem Sets	25%
Lab Activity Reports	20%
Seminar paper presentation and written analysis	15%
Participation in Seminar/Class Discussion & Labs	25%
Total	**100%**

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Rm MCZ 100 ('Oceanography' Seminar Rm) access from Oxford St or via Divinity Ave & rear courtyard