1. EM478 Biological Fluid Dynamics

2. Credit Hours (3)/Contact Hours (3)

3. Course Director – Cody J. Brownell

4. no text

5. Specific course information

a. Analysis of fluid flow in and around biological systems, focusing on the mechanics of swimming, flying, and breathing. Two major themes of the course are the effect of scale on evolutionary form and function, and the relationships between biological inspiration, physical understanding, and engineering design. Fluid dynamics concepts from the prerequisite course will be expanded to include vortex dynamics, Stokes flow, and the structure of turbulence. Course will have a final paper in lieu of an exam.
b. Prerequisites: EM316 or EM324
c. Mechanical Engineering Major Elective.

6. Educational objectives for the course

a. Apply dimensional analysis to biological flows.
b. Recognize the Navier-Stokes equations and explain their use in biological fluid mechanics.
c. Describe the characteristics of turbulent flows, and describe how turbulence affects swimming, flying, and breathing.
d. Describe the dominant drag mechanisms for marine organisms, and identify active and passive drag reduction strategies.
e. Classify aquatic propulsion modes, and explain the generation of thrust in aquatic swimmers.
f. Identify and classify birds by their wing type and other aerodynamic features.
g. Explain insect flight mechanisms including the formation and use of leading edge vortices.
h. Demonstrate the ability to find and use academic literature to answer questions on biological fluid mechanics.

7. Specific program outcomes addressed by this course

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Reinforced							X
Mastered	X		X				

8. Brief list of topics to be covered
    a. Review of Fluid Dynamics
        i. Conservation laws for mass, momentum and energy
        ii. Dimensional analysis
    b. Scale in Biological Systems
        i. Navier-Stokes equations and their non-dimensional forms
        ii. Applications of dimensional analysis to biological systems
    c. Swimming
        i. Quantifying drag and thrust
        ii. Fish anatomy and swimming modes
        iii. Elongated body theory
        iv. Human competitive swimming
    d. Flying
        i. Vortex dynamics, Potential flow and lift
        ii. Wing types
        iii. Methods to augment flight
        iv. Tail shapes
        v. Low-Re aerodynamics
        vi. Leading edge vortices
    e. Breathing
        i. Mixing and turbulence
        ii. Diffusive processes and Fick's Law
        iii. Gill structure and function; counter-flow
        iv. Respiration in insects and amphibians
        v. Avian respiratory system
        vi. Lung Structure
        vii. Infectious disease fluid dynamics
    f. Research methods