UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION APRIL 1999
AER307S-AERODYNAMICS
2 1/2 hours: Exam Type: X; Answer all questions
Examiner: Prof. J. D. DeLaurier

1. A "flat" rotor called a "Wells Turbine" (shown in Figure 1) is used to extract energy from the rise and fall of ocean waves. *The* blades have no pitch or twist angles relative to the axis of rotation. *Describe* what makes this work. (10 points)

2. The Weis-Fogh "Clap-Fling" mechanism for generating lift was described in class. *For* the initial opening, as shown in Figure 2,

a) describe the role of the Kutta Condition. (5 points)
b) Is Kelvin's Circulation Theorem obeyed? (5 points)
c) The instance after the wings come apart, sketch the streamline pattern over an airfoil on the wing. (5 points)

3. For the airfoil shown in Figure 3, use thin-airfoil theory to find α_{l_o} and $(C_m)_{l.e.}$ (30 points)

4. Two birds are gliding in formation as shown in Figure 4. *The* birds weigh 28 N each, and are flying at 20 m/sec through air whose density is $\rho = 1.225$ kg/m^3. *Assume* a simple horseshoe vortex model for lift.

a) Find the strength, Γ, of the vortex. (10 points)
b) Find the induced velocity at pt. 2 due only to bird #1. (15 points)
c) Find the induced velocity at pt. 2 due only to bird #2. (10 points)
d) What is the effect of bird #1 on the downwash of bird #2, and how would this affect bird #2's induced drag? (10 points)

Figure 1

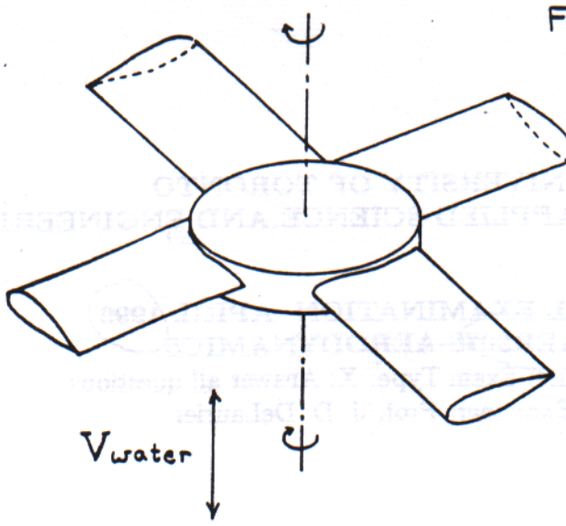
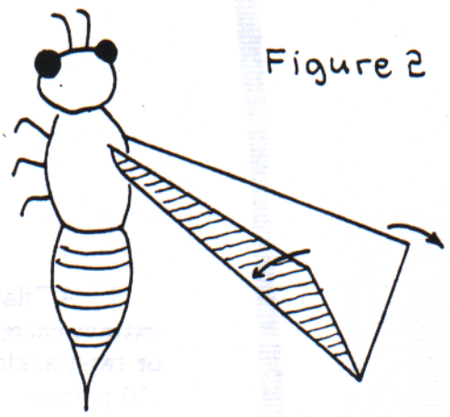


Figure 2



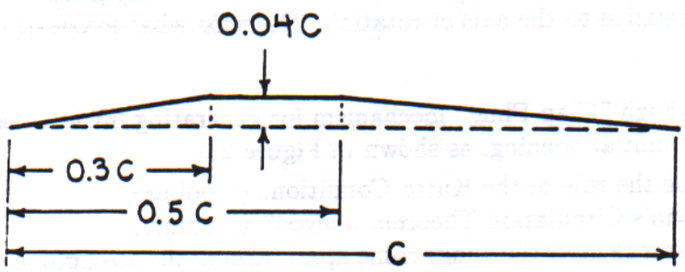


Figure 3

Figure 4