THE UNIVERSITY OF TEXAS AT AUSTIN
Department of Aerospace Engineering and Engineering Mechanics

ASE 367K FLIGHT DYNAMICS
Fall 2024

HOMEWORK 1
Due: Friday 2024-09-06 at 11:59pm via Canvas

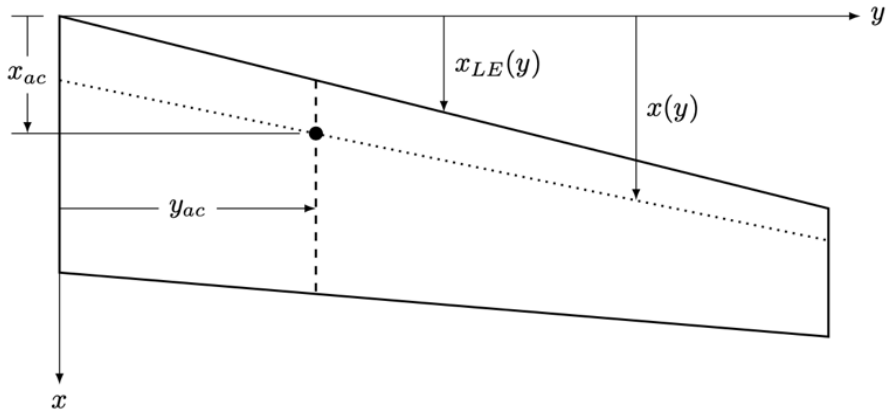
Problem 1

Explain (in terms of their effect on profile and induced drag) why a dimpled golf ball has lower drag than a smooth golf ball. State the condition that must be true for the overall drag to be reduced. HINT: Consider the relative changes in the magnitude of the two drag components when dimples are introduced.

Problem 2

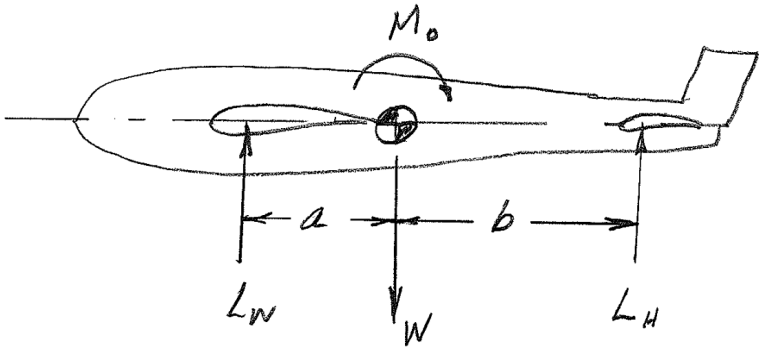
Assuming the wing of the 747-400 is trapezoidal (see figure below), use publicly available data to compute the following parameters and explain why the wing sweep of the 747-400 is/is not the same as the wing sweep of the 737-900 (that we computed during the second lecture).

a. planform area
b. aspect ration
c. leading edge wing sweep
d. trailing edge wing sweep
e. mean aerodynamic chord
f. lateral location of the aerodynamic center
g. longitudinal location of the aerodynamic center



Problem 3

Using your knowledge of statics and our discussion in the second lecture, derive expressions for the equilibrium pitch angle θ_0 and the equilibrium elevator deflection angle δ_0 of the aircraft in the following diagram:



in terms of the parameters in the following equations for the lift generated by the wing (positive lift upwards):

$$L_W = \frac{1}{2}\rho V^2 S C_{L_W} \; where \; C_{L_W} = C_{L_{W_0}} + C_{L_{W_\alpha}}\alpha$$

and the lift generated by the horizontal stabilizer (positive lift upwards):

$$L_H = \frac{1}{2}\rho V^2 S_H C_{L_H} \; where \; C_{L_H} = C_{L_{H_0}} + C_{L_{H_\alpha}}\alpha + C_{L_{H_\delta}}\delta$$

Problem 4

Using your knowledge of statics and dynamics, and our discussion in the second lecture, derive the matrix equation

$$\begin{bmatrix} \ddot{h} \\ \ddot{\theta} \end{bmatrix} = \begin{bmatrix} \frac{gC_{L_\theta}}{W} & \frac{gC_{L_\delta}}{W} \\ \frac{C_{M_\theta}}{I} & \frac{C_{M_\delta}}{I} \end{bmatrix} \begin{bmatrix} \Delta\theta \\ \Delta\delta \end{bmatrix} \cdots$$

and:

a. Provide expressions for $C_{L_\theta}, C_{L_\delta}, C_{M_\theta}, and \; C_{M_\delta}$ in terms of the parameters in the equations for the lift generated by the wing and the lift generated by the horizontal stabilizer.

b. What must be true, assuming $C_{L_{H_\delta}} = C_{L_{H_\alpha}}$, about the relationship between $C_{L_{H_\alpha}}$ and $C_{L_{W_\alpha}}$ for C_{M_θ} to be negative?

c. How would direction (sign) of L_H change if the center of gravity was in front of the aerodynamic center of the wing?

d. What would be the implication be for the relationship between $C_{L_{H_\alpha}}$ and $C_{L_{W_\alpha}}$ for C_{M_θ} to remain negative?