**University of Dayton**

Department of Mechanical and Aerospace Engineering

**MEE 440/AEE 521 – Flight Vehicle Performance/Dynamics**

**Homework-**

1. For the aircraft assigned to you and use the corresponding aircraft data, provided drawings. Extract the relevant geometric parameters and provide estimates for all the longitudinal coefficients.

### Wing Geometric Parameters

- $C_T =$ 4.5
- $\Lambda_{LE} =$ ~~1.0~~ 0.0262
- $C_R =$ 6.2
- $b =$ 33.8
- $X_{WH_R} =$ 15.9
- $Z_{WH} =$ $Z_{WH_R}$ ? (3)
- $b_H =$ 14.0
- $c_{T_H} =$ 2.2
- $c_{R_H} =$ 4.6
- $\Lambda_{LE_H} =$ ~~12.5~~ 0.2182
- $\lambda = \frac{c_T}{c_R} =$ 0.72
- $S = \frac{b}{2}c_R(1+\lambda) =$ 180.83 ft²
- $AR = \frac{b^2}{S} =$ 6.318
- $\bar{c} = MAC = \frac{2}{3}c_R\frac{1+\lambda+\lambda^2}{1+\lambda} =$ 7.133
- $x_{MAC} = \frac{b}{6}\frac{(1+2\lambda)}{(1+\lambda)}\tan(\Lambda_{LE}) =$ ~~12.85~~ 0.2096
- $\tan(\Lambda_x) = \tan(\Lambda_{LE}) - \frac{4x(1-\lambda)}{AR(1+\lambda)}$
  - $\tan(\Lambda_{0.5}) =$ -0.0241
  - $\tan(\Lambda_{0.25}) =$ 0.0010

### Modeling Downwash Coefficients

- $K_{AR} = \frac{1}{AR} - \frac{1}{1+(AR)^{1.7}}$ = 0.1165
- $K_\lambda = \frac{10-3\lambda}{7}$ = 1.1175
- $K_{mr} = \frac{1-\frac{m}{2}}{(r)^{0.33}}$ → $(r)^{0.33}$ = ~~3.0108~~ 0.9376
- $\left(\frac{d\epsilon}{d\alpha}\right)\Big|_{Mach=0} = 4.44\left(K_{AR}K_\lambda K_{mr}\sqrt{cos(\Lambda_{0.25})}\right)^{1.19}$ = 0.5422

### Horizontal Tail Parameters

- $\lambda_H = \frac{c_T}{c_R} = \frac{C_T}{C_R}$ = ? = 0.478
- $S_H = \frac{b_H}{2}c_R(1+\lambda_H) =$ ~~47.6~~ 74.9
- $AR_H = \frac{b_H^2}{S_H} =$ ~~4.1176~~ 2.6168
- $\bar{c}_H = \frac{2}{3}c_{R_H}\frac{1+\lambda_H+\lambda_H^2}{1+\lambda_H} =$ ~~3.5412~~ 4.0028 0.7348
- $x_{MAC_H} = \frac{b_H}{6}\frac{(1+2\lambda_H)}{(1+\lambda_H)}\tan(\Lambda_{LE_H}) =$ ~~-0.205~~
- $\tan(\Lambda_{0.5_H}) =$ 0.1714 $\Lambda_{0.5_H} = 0.1697$

### Wing Tail Geometric Parameters

- $X_{WH} = X_{W_{HR}} + \frac{c_{R_H}}{4} - \frac{c_R}{4}$ = 15.5
- $r = \frac{2X_{WH}}{b} =$ 0.9172
- $m = \frac{2Z_{WH}}{b} =$ 0.1775
- $x_{AC_H} = X_{WH_R} + x_{MAC_H} + \frac{\bar{c}_H}{4} - x_{MAC}$ = 17.426
- $\bar{x}_{AC_H} =$ $\frac{x_{AC_H}}{\bar{c}}$ = 2.44

### Wing Lift-Slope Coefficients

- $K = 1 + \frac{(8.2-2.3\Lambda_{LE})-AR(0.22-0.153\Lambda_{LE})}{100}$ = 1.0678
- $c_{L_{\alpha_W}|_{Mach}} =$ 16.18

### Horizontal Tail Lift-Slope Coefficients

- $k_H = \frac{(8.2-2.3\Lambda_{LE_H})-AR_H(0.22-0.153\Lambda_{LE_H})}{100} + 1 =$ 1.0721 9.19
- $c_{L_{\alpha_H}|_{Mach}} =$ 4.09

- $c_{L\alpha_{W|Mach=0}} = \frac{2\pi AR}{2+\sqrt{\left[\frac{AR^2}{k^2}\left(1+tan^2(\Lambda_{0.5})\right)\right]+4}}$ = 4.8131

Wing Slope Coeff. Asumption

- $\left(\frac{d\epsilon}{d\alpha}\right)|_{Mach} = \left(\frac{d\epsilon}{d\alpha}\right)|_{Mach=0} \frac{c_{L\alpha_{W|Mach=0}}}{c_{L\alpha_{W|Mach}}}$ = 0.1613

**Wing Aerodynamic Center** → Napolite

- $\bar{x}_{AC_W} = K_1\left(\frac{x\prime_{AC_W}}{c_R} - K_2\right) =$ -0.655
  - $\frac{\tan(\Lambda_{LE})}{\sqrt{1-M^2}} =$ -0.685
  - $AR * \tan(\Lambda_{LE}) =$ -0.821

Pg. 54-55

Where?

- Figure 2.27: $\lambda = 0.25, AR * tan(\Lambda_{LE}) = 4.5827 \Rightarrow \frac{x\prime_{AC}}{c_R} =$ 0.19
- Figure 2.28: $\lambda = 0.25 \Rightarrow K_1 =$ 1.425
- Figure 2.29: $\Lambda_{LE} = 28°, \lambda = 0.25, AR = 8.612 \Rightarrow K_2 =$ 0.65
- $\bar{x}_{AC_W} = K_1\left(\frac{x\prime_{AC}}{c_R} - K_2\right) =$ -0.655
- $\Delta\bar{x}_{AC_B} == -\frac{1}{2.92S\bar{c}} \sum_{i=1}^{N} w_{B_i}^2 (\frac{d\bar{\epsilon}}{d\alpha}{}_i)\Delta x_i =$ -0.198
- $\bar{x}_{AC_{WB}} = \bar{x}_{AC_W} + \Delta\bar{x}_{AC_B} =$ -0.8455

**Aerodynamic Parameters**

- $C_{L_\alpha} =$ 3.215
- $C_{L_{\delta_E}} =$ 0.3172
- $C_{L_{i_H}} =$ 0.6344
- $C_{m_\alpha} =$ -0.17
- $C_{m_{\delta_E}} =$ -1.12
- $C_{m_{i_H}} =$ 0
- $C_{L_{\dot{\alpha}}} =$ 0.429
- $C_{L_q} =$ 45.6 *Wrong
- $C_{m_{\dot{\alpha}}} =$ -6.95
- $C_{m_q} =$ -18.7 (from book)

Lecture 7:
End