

ERRATA: Airplane Flight Dynamics and Automatic Flight Controls Part I

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<i>page iii, line 3</i>	Topic 3.2.17 Review of Important Sign Conventions should be removed																			
<i>page x, line 4</i>	The second word ‘control’ in the description of the $c_{l\delta}$ should be deleted																			
<i>pages vii – xxviii</i>	Add the following symbols and descriptions																			
	<table border="0"> <thead> <tr> <th style="text-align: left;"><u>Symbol</u></th> <th style="text-align: left;"><u>Description</u></th> <th style="text-align: left;"><u>Unit</u></th> </tr> </thead> <tbody> <tr> <td><i>page xxii</i></td> <td>X, Y, Z</td> <td>Body-fixed (rotating) axis system</td> <td>--</td> </tr> <tr> <td><i>page xxii</i></td> <td>X', Y', Z'</td> <td>Earth-fixed (non-rotating) axis system</td> <td>--</td> </tr> <tr> <td><i>page xxvi</i></td> <td>1, 2, 3</td> <td>Eular rotation sequence (the use of the symbol “1” to denote the first Euler rotation is used only in Chapter 1)</td> <td></td> </tr> <tr> <td><i>page xxvii</i></td> <td>P</td> <td>Origin of the XYZ system</td> <td></td> </tr> </tbody> </table>	<u>Symbol</u>	<u>Description</u>	<u>Unit</u>	<i>page xxii</i>	X, Y, Z	Body-fixed (rotating) axis system	--	<i>page xxii</i>	X', Y', Z'	Earth-fixed (non-rotating) axis system	--	<i>page xxvi</i>	1, 2, 3	Eular rotation sequence (the use of the symbol “1” to denote the first Euler rotation is used only in Chapter 1)		<i>page xxvii</i>	P	Origin of the XYZ system	
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<i>page xiii</i>	In the fourth line from the bottom, C_X should be C_Z																			
<i>page xxii – xxiii</i>	Remove the negative sign in all lateral acceleration equations.																			
<i>page xxv, 6th line</i>	μ_g should be dimensionless.																			
<i>page 6, Eqn. (1.7)</i>	r'_p should be \bar{r}'_p .																			
<i>page 7, before Eqn (1.14)</i>	Should read: ‘The transformation formulaof both equations (1.11) and (1.12). First , for the l.h.s. of Eqn (1.11):’																			
<i>page 17, Fig 1.7</i>	The aircraft of the lowest figure should be seen from behind, i.e. a positive bank angle should have right wing down.																			
<i>page 43, Fig 2.6</i>	S_{wf} should be $\frac{S_{wf}}{2}$																			
<i>page 44, Eqn. (2.16)</i>	$S_{wf} = S \frac{(\eta_o - \eta_i)}{(1 + \lambda)} \left[2 - (1 - \lambda)(\eta_i + \eta_o) \right]$																			

- page 47 First paragraph under 2.5.2 second line. “In variant” should be “invariant”
- page 51 Second paragraph 8th line. “top” should be “to”
- page 55, Eq (2.27) should be $\left(\frac{d\varepsilon}{d\alpha}\right)_M = \frac{\left(\frac{d\varepsilon}{d\alpha}\right)_{M=0}}{\sqrt{(1-M^2)}}$
- page 84, Eq (3.30) in $\cos(\alpha + i_w - \varepsilon)$ “i_w” should be “i_h”
- page 95 Last full paragraph, 4th line. After “vortices” add “(at high angles of attack)”
- page 63, Problem 2.3 the set of data under data set “a” should be data set “c”
- page 67 change loose in lose.
- page 72, Eqn (3.5) C_{D0} is the value of C_D for: $\alpha = i_h = \delta_e = 0$
- page 77, Eqn (3.12) C_{L0} is the value of C_L for: $\alpha = i_h = \delta_e = 0$
- page 80, Eqn (3.29) C_{m0} is the value of C_m for:
- page 84,
Eqn (3.32) Should be:
- $$C_m = C_{mac_{wf}} + \left(C_{L0_{wf}} + C_{L\alpha_{wf}} \alpha \right) (\bar{x}_{cg} - \bar{x}_{ac_{wf}}) - C_{L\alpha_h} \eta_h \frac{S_h}{S} (\bar{x}_{ac_h} - \bar{x}_{cg}) \left[\alpha - \left(\varepsilon_o + \frac{d\varepsilon}{d\alpha} \alpha \right) + i_h + \tau_e \delta_e \right]$$
- 4th line from bottom A reference to Eqn (3.33) should be Eqn (3.32).
- page 98, 11th line from top ‘three-vies’ should be ‘three-views’.
- page 104 change loose in lose.
- page 108 Figure 3.38, the subscripts “v” should be taken out from the two variables $F_{ay_{rudder}}$ and $N_{A_{rudder}}$
- Page 108 Eqn (3.71) $C_{l_{\delta_r}} = C_{L\alpha_v} \alpha_{\delta_r} \eta_v \frac{S_v x_{v_s}}{Sb}$ replaces $C_{l_{\delta_r}} = C_{L\alpha_v} \alpha_{\delta_r} \bar{q}_v \frac{S_v x_{v_s}}{Sb}$
- page 109, Eq (3.72) multiply right side quantity by $\bar{q}Sb$

<i>page 111, Eqn (3.76)</i>	Should read: $F_{A_{y_v}} = C_{y_{\beta_v}} \beta \bar{q} S = -C_{L_{\alpha_v}} \left(1 - \frac{d\sigma}{d\beta} \right) \bar{q}_v S_v$
<i>page 113</i>	Equation (3.78), the subscripts “v” should be taken out from the variables $F_{a_{y_{rudder}}}$
<i>page 113</i>	Equation (3.80) should be multiplied by: $\bar{q} S$
<i>page 121, Eq (3.91)</i>	multiply right side quantity by $\bar{q} S b$
<i>page 122, Eqn (3.92a)</i>	Should be $L_{T_{1_s}} = \dots = \left[\sum_{i=0}^{i=n} T_i \left(-z_{T_i} \cos \phi_{T_i} \sin \psi_{T_i} - y_{T_i} \sin \phi_{T_i} \right) \right] \cos \alpha_1 + \dots$
<i>Eqn (3.92c)</i>	Should be $N_{T_{1_s}} = \dots = \dots - \left[\sum_{i=0}^{i=n} T_i \left(-z_{T_i} \cos \phi_{T_i} \sin \psi_{T_i} - y_{T_i} \sin \phi_{T_i} \right) \sin \alpha_1 \right]$
<i>page 137, 6th line from bottom</i>	Should read ‘... are affected by changes in angle of attack, α : ...’.
<i>page 139</i>	Equation (3.133), change the subscript “x” to “z” in $\frac{\partial F_{A_z}}{\partial \alpha}$
<i>page 143, right after Eqn (3.146)</i>	Should read ‘... multiplying by the non-dimensional moment ...’
<i>page 147</i>	Equation (3.162), replace the variable C_{L_1} in (2,1) entry to C_{D_1}
<i>page 148</i>	Equations (3.163a, b, c), the negative signs should be removed
<i>page 148, Section 3.2.10</i>	First paragraph “changes in sideslip, β ” should be “changes in sideslip rate, $\dot{\beta}$ ” Second paragraph “sideslip angle, β ” should be “sideslip rate, $\dot{\beta}$ ”
<i>page 157, Eqn. (3.189)</i>	$C_{y_r} \approx C_{y_{r_v}} = C_{L_{\alpha_v}} \left(\frac{2x_{v_s}}{b} \right) \eta_v \left(\frac{S_v}{S} \right)$
<i>page 167, Eq (3.214)</i>	Insert “+ u” in denominator. $F_{T_x} = \frac{n_p 550 \eta_p BHP}{U_1 + u}$
<i>page 168, Eqn. (3.223)</i>	$C_{X_{T_u}}$ should be $C_{T_{X_u}}$ This change should also be made in text above Eqn. (3.223)

<i>page 173</i>	First paragraph, 5 th line. The word “be” is duplicated and should be deleted
<i>page 174, Eqn (3.248)</i>	‘ 0_{0_0} ’ should be ‘0’(zero).
<i>page 186</i>	Equation (4.3), remove the variable U_1
<i>page 189</i>	Equation (4.7), remove the negative sign
<i>page 189</i>	The line below Equation (4.7), change (4.1) to (4.6)
<i>page 195</i>	Equation (4.36), remove the variable U_1
<i>page 198, 1st line</i>	‘(4.22)’ should be ‘(4.42)’.
<i>page 199, after Eqn (4.45)</i>	Should read: ‘ $C_{L_1} \approx \frac{mg}{\bar{q}_1 S}$ ’. Note that $\cos \gamma_1 \approx 1.0$.
<i>page 208, Fig. 4.10</i>	In the graph on the left, $\bar{x}_{cg} = 0.15$ should be $\bar{x}_{cg} = 0.30$ and $\bar{x}_{cg} = 0.30$ should be $\bar{x}_{cg} = 0.15$
<i>page 209, Fig 4.11b</i>	The negative tail stall locus as shown in the diagram is wrong. The trim diagram should have a positive tail stall locus at $\alpha = 25^0$ and a negative tail stall locus at $\alpha = -12^0$. Both of these lines are out of the range of the diagram so none of them should be shown.
<i>page 211, 11th line</i>	The corresponding values for $\alpha_{\text{tail-stall}}$ should be -12^0 and 25^0 , respectively. Also, the tail stall locus should not be shown in Figure 4.11b because they are outside the range of the diagram.
<i>page 218, 8th line from bottom</i>	‘ F_{STO} ’ should be ‘ V_{STO} ’.
<i>page 219, Table 4.3</i>	In Eqn. (4.76), change δ_{a_1} to δ_{r_1}
<i>page 220, Eqn. (4.81)</i>	Remove \bar{q} from the equation.
<i>page 221, Fig. 4.15</i>	$\beta = -15^\circ$ should be $\beta = -10^\circ$
<i>Fig 4.16a</i>	The lateral axis should be the Y-axis. Also, the bank angle is negative as shown.
<i>page 226, Eqn (4.89)</i>	On the right-hand side of the equation, $\tan \phi_1$ should be in the denominator
<i>Eqn (4.90)</i>	ψ_1 should read $\dot{\psi}_1$

- Eqn (4.95) Should be $mU_1 R_1 = mg \sin \phi_1$.
- Eqn (4.106) The ‘(’ in between ‘n’ and ‘ C_{Ltrim} ’ should be in front of ‘n’.
- page 228, Eq (4.100) δ_{a_1} should read δ_{η}
- page 233 Third paragraph, 2nd line. The word “forward” should be changed to “aft”
- page 235,
Conclusion for Sec. 4.4.1 The inequality should be $|M_{ac_{wf}}| < L_{wf}(x_{cg} - x_{ac_{wf}})$.
- page 236,
Conclusion for Sec. 4.4.2 The inequality should be $|M_{ac_{wf}}| < L_{wf}(x_{cg} - x_{ac_{wf}})$.
- page 244, Section 4.5.1 Last paragraph, change $\eta_h = \frac{\bar{q}}{\bar{q}_h}$ to $\eta_h = \frac{\bar{q}_h}{\bar{q}}$
- page 250, (cont.)
Eqn (4.147) Eqn (4.147) is derived from Eqn (4.140) and it should be:
- $$C_{h_{otrim}} = - \left\{ C_{h\alpha} \left(1 - \frac{d\varepsilon}{d\alpha} \right) \alpha_{C_{L_1=0}} + C_{h\alpha} (i_h - \varepsilon_o) + C_{h\delta_e} \delta_{e_{C_{L_1=0}}} \right\} \\ - C_{L_1} \left\{ \frac{C_{h\alpha} C_{m\delta_e} \left(1 - \frac{d\varepsilon}{d\alpha} \right) - C_{h\delta_e} C_{m\alpha}}{\left(C_{L\alpha} C_{m\delta_e} - C_{m\alpha} C_{L\delta_e} \right)} \right\}$$
- page 252,
2nd line Should read ‘... differentiating Eqn (4.148) with respect to the angle of attack.’
- Eqn (4.150) The first term on the RHS of Eqn (4.150) should be $C_{L\alpha_{wf}} (\bar{x}_{cg} - \bar{x}_{ac_{wf}})$.
- Eqn (4.154) Second row: Delete the ‘)’ after $\frac{C_{h\alpha} \tau_e}{C_{h\delta_e}}$.
Last row: Delete the ‘ τ_e ’ and the ‘)’ after it.
- page 253, Eqn 4.158 Remove the ‘ τ_e ’ from the equation.
- page 256,
Eqn (4.171) Should be
- $$MP_{free} = \bar{x}_{cg} \frac{\partial F_s}{\partial n=0} = NP_{free} - \left(1 - \frac{C_{h\alpha} \tau_e}{1.1 C_{h\delta_e}} \right) \left(\frac{\rho S \bar{c} g}{4W} \right) C_{mq}$$

page 267

Definitions for each variable should be: $C_{h_{\delta_r}}, C_{h_{\delta_n}}, C_{h_{\beta_v}}$ normally negative, negative, positive respectively

page 268

Include in τ_r definition: $\tau_r = \frac{\partial \beta}{\partial \delta_r}$ and is normally negative

page 268, Fig 4.43

Signs on hingemoment derivatives are reversed.

$$C_{h_{\beta_v}} > 0$$

$$C_{h_{\delta_r}} < 0$$

page 269,
Eqn. 4.197

$$C_{n_{\beta_v} \text{ free}}$$

$$= C_{L\alpha_v} \eta_v \frac{S_v x_{v_s}}{Sb} \left(1 - \frac{C_{h_{\beta_v}}}{C_{h_{\delta_r}}} \left(1 - \frac{\partial \sigma}{\partial \beta} \right) \tau_r \right) - C_{L\alpha_v} \eta_v \frac{S_v x_{v_s}}{Sb} \frac{\partial \sigma}{\partial \beta}$$

Eqn. 4.198

$$C_{n_{\beta} \text{ free}} = C_{n_{\beta} \text{ fix}} - C_{L\alpha_v} \eta_v \frac{S_v x_{v_s}}{Sb} \frac{C_{h_{\beta_v}}}{C_{h_{\delta_r}}} \left(1 - \frac{\partial \sigma}{\partial \beta} \right) \tau_r$$

Eqn. 4.199

$$C_{n_{\beta} \text{ free}} = C_{n_{\beta} \text{ fix}} - C_{n_{\delta_r}} \frac{C_{h_{\beta_v}}}{C_{h_{\delta_r}}} \left(1 - \frac{\partial \sigma}{\partial \beta} \right)$$

page 269, (cont.)

Eqn. 4.203

$$\frac{\partial F_r}{\partial \beta} = \frac{G_r \eta_v \bar{q} S_r \bar{c}_r C_{h_{\delta_r}}}{C_{n_{\delta_r}}} C_{n_{\beta} \text{ free}}$$

page 277,

1st line after Eqn (4.221c)

The symbol ' \bar{C}_{D_o} ' should be ' C_{D_o} '.

page 281

Extra period after stick-force trim

List at end of page is inconsistent with Figure 4.49

page 291

Last paragraph, 1st line. The word "are" should be "area"

page 299, Problem 4.5

'Eqn (4.155)' should be 'Eqn (4.159)'.

page 307, Eqn (5.1a)

Insert θ after mg .

$$\begin{aligned} \dot{m}u = & -mg\theta \cos \theta_1 + \bar{q}_1 S \left\{ -\left(C_{D_u} + 2C_{D_1}\right) \frac{u}{U_1} + \left(C_{T_{x_u}} + 2C_{T_{x_1}}\right) \frac{u}{U_1} + \right. \\ & \left. -\left(C_{D_\alpha} - C_{L_1}\right) \alpha - C_{D_{\delta_e}} \delta_e \right\} \end{aligned}$$

page 307, Eqn (5.1b)

Insert θ after mg .

$$m(\dot{w} - U_1 q) = -mg\theta \sin \theta_1 + \bar{q}_1 S \left\{ -\left(C_{L_u} + 2C_{L_l}\right) \frac{u}{U_1} - \left(C_{L_\alpha} + C_{D_l}\right) \alpha + \right. \\ \left. - C_{L_{\dot{\alpha}}} \frac{\dot{\alpha} \bar{c}}{2U_1} - C_{L_q} \frac{q \bar{c}}{2U_1} - C_{L_{\delta_e}} \delta_e \right\}$$

page 307, Eqn (5.1c)

Should be

$$I_{yy} \dot{q} = \bar{q}_1 S \bar{c} \left\{ \left(C_{m_u} + 2C_{m_l}\right) \frac{u}{U_1} + \left(C_{m_{T_u}} + 2C_{m_{T_l}}\right) \frac{u}{U_1} + C_{m_\alpha} \alpha + C_{m_{T_\alpha}} \alpha + \right. \\ \left. + C_{m_{\dot{\alpha}}} \frac{\dot{\alpha} \bar{c}}{2U_1} + C_{m_q} \frac{q \bar{c}}{2U_1} + C_{m_{\delta_e}} \delta_e \right\}$$

page 318, 5th line

Should read 'w = U₁α'.

page 322, Eqn. (5.34)

Equation for C₁ should read as follows:

$$C_1 = \left(X_u + X_{T_u}\right) \left\{ M_q \left(U_1 - Z_{\dot{\alpha}}\right) + Z_\alpha + M_{\dot{\alpha}} \left(U_1 + Z_q\right) \right\} + \\ + M_q Z_\alpha - Z_u X_\alpha + M_{\dot{\alpha}} g \sin \theta_1 - \left(M_\alpha + M_{T_\alpha}\right) \left(U_1 + Z_q\right)$$

page 332, Eq (5.53)

the equation should have a minus “ - “ before ζ_{1,2}ω_{n1,2} and ζ_{sp}ω_{nsp}

page 333, Eq (5.54)

the equation should have a minus “ - “ before ζ_{3,4}ω_{n3,4} and ζ_{ph}ω_{nph}

page 333, Eq (5.56)

the equation should have a minus “ - “ before ζ_{3,4}ω_{n3,4} and ζ_{3rd}ω_{n3rd}

page 338

Equation (5.69),
$$\frac{\theta(s)}{\delta_e(s)} = - \frac{\left(Z_{\delta_e} s - X_u Z_{\delta_e} + X_{\delta_e} Z_u\right)}{U_1 \left(s^2 - X_u s - \frac{g Z_u}{U_1}\right)}$$

page 340

3rd line. The word “ration” should be “ratio”

page 340

Equation (5.76), the term Z_{δ_e}M_α should be -Z_{δ_e}M_α

page 340

Equations (5.76) to (5.78), change D₁ to \bar{D}_1

page 344,
Eqn. (5.88)

Change the term -g sin θ₁ to -g cos θ₁

Eqn (5.92)

Should be
$$Magnitude = \sqrt{\frac{n_{num}^2 + \omega_{num}^2}{n_{den}^2 + \omega_{den}^2}}$$

page 345, Fig 5.14

The mode descriptions are reversed. a) should be Phugoid Mode Shape and b) should be Short Period Mode Shape

- page 346, Eqn (5.94) The (3,3) element of the transformation matrix should be ‘ $\cos 2\alpha_1$ ’ instead of ‘ $\cos^2 \alpha_1$ ’.
- page 349, Table 5.8 The left-hand side of Eqn. (5.96c) should be $\ddot{\psi} - \bar{B}_1 \ddot{\phi}$
- page 357, 2nd line The ‘(pitching moment of inertia)’ should be replaced by ‘(moments and products of inertia)’.
- page 364, Eqn (5.120b) The equation should be numbered as (5.119b).
- page 364, Eqn 5.121 $\frac{\sqrt{C_{n\beta} \bar{q}_1 S b}}{I_{zz}}$ should be replaced with $\sqrt{\frac{C_{n\beta} \bar{q}_1 S b}{I_{zz}}}$
- page 371 Equations (5.136) to (5.138), change D_2 to \bar{D}_2
- page 372, last line ‘ $\psi(\tau)$ ’ should be ‘ $\psi(t)$ ’.
- page 383 Remove the two lines before *Section 5.4.3*.
- page 397, Sec. 5.5.2 In the third line of text change ζ_{sp} to ζ_d
- page 398, Eqn. (5.161) On the right-hand side of the equation change \bar{c} to b .
- In the two paragraphs following Eqn. (5.162), change all the references of pitch to yaw. Also, in the second paragraph following the words 10 deg/deg/sec, remove the phrase “a pitch”.
- page 399 In the paragraph following Eqn. (5.169), the equation describing the resulting induced angle of attack should read:

$$22 \times 57.3 / (1.688 \times 516) = 1.4 \text{ deg.}$$
Also, in the following line, the canard deflection command should be -2.6 deg .
- page 400, 4th line above Sec. 5.6.1 ‘Eqns (5.76)’ should be ‘Eqns (1.76)’ instead.
- page 403 In the line of text preceding Eqn. (5.194), change $(P_1)^2$ to $(P_1)^4$
- page 411, Problem 5.13 Last sentence should read: ‘How well do these results agree with your conclusions from problem 5.12?’.
- page 424, Table 6.4 The Civilian Requirements FAR-23 are updated to the following:
For wheel controllers:

$$\frac{\partial F_s}{\partial n} > \frac{(W_{TO}/100)}{n_{limit}} \text{ and } \frac{20.0}{n_{limit}}$$
but not more than: $\frac{50.0}{n_{limit}}$

For stick controllers:

$$\frac{\partial F_s}{\partial n} > \frac{W}{140} \text{ and } \frac{15.0}{n_{\text{limit}}}$$

but not more than: $\frac{35.0}{n_{\text{limit}}}$

page 437, Table 6.12

Sixth line of text from bottom of table, replace value with value.

page 438, Table 6.14

All inequalities involving the roll mode time constant, T_r should be \leq for all Flight Phase Categories and Levels. For all Flight Phase Categories and Airplane Classes, Level 3 should read $T_r \leq 10.0$ sec. Also, disregard the footnote referring to MIL-STD-1797A.

page 453, Table 6.22

The number in the last column is referenced from Figure 6.16 instead of Figure 6.15.

page 456,

Eqn (6.26)

$$\text{Should be: } \Delta\delta_{e_{gust}} = \frac{(1.10 - 0.0322S_h)}{-0.023S_h} \Delta\alpha_{gust}.$$

page 457, Fig 6.18

The ' $\Delta\delta_{e_{gust}}$ ' curve is plotted with $\Delta\alpha_{gust} = 1.8$ deg .

page 551, Appendix C

In the first line of text remove the word "those".

Please check the website www.darcorp.com for updated errata