Errata for the First Printing of
Control of Biological and Drug-Delivery Systems for Chemical, Biomedical, and Pharmaceutical Engineering

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Chapter 1

C1. Page 8: In Figure 1.6, replace "Bioreceptor sensor system" with "Baroreceptor sensor system".

Chapter 3

C2. Page 50: Eq. (3.24) should be

$$f(y,u) \approx f(y_0,u_0) + \frac{(y-y_0)}{1!}\left(\frac{\partial f}{\partial y}\right)_{y_0,u_0} + \frac{(u-u_0)}{1!}\left(\frac{\partial f}{\partial u}\right)_{y_0,u_0}$$

$$f(y,u) \approx f(2,0) + \frac{(y-2)}{1!}\left(\frac{\partial f}{\partial y}\right)_{(y_0,u_0)=(2,0)} + \frac{(u-0)}{1!}\left(\frac{\partial f}{\partial u}\right)_{(y_0,u_0)=(2,0)}$$

$$f(y,u) \approx 0 + (y-2)\times(2) + (u-0)(1)$$

$$f(y,u) \approx 2(y-2) + (u-0)$$

$$\frac{dy}{dt} \approx 2(y-2) + (u-0)$$

C3. Page 53: Eq. (3.32) should be $\mathbf{A} = \begin{bmatrix} \left(\frac{\partial f_1}{\partial x_1}\right)_P & \left(\frac{\partial f_1}{\partial x_2}\right)_P & \cdots & \left(\frac{\partial f_1}{\partial x_n}\right)_P \\ \left(\frac{\partial f_2}{\partial x_1}\right)_P & \left(\frac{\partial f_2}{\partial x_2}\right)_P & \cdots & \left(\frac{\partial f_2}{\partial x_n}\right)_P \\ \vdots & \vdots & \vdots & \vdots \\ \left(\frac{\partial f_n}{\partial x_1}\right)_P & \left(\frac{\partial f_n}{\partial x_2}\right)_P & \cdots & \left(\frac{\partial f_n}{\partial x_n}\right)_P \end{bmatrix}$

C4. Page 56: Eq. (3.43) should be $\frac{dy}{dt} = \beta - \alpha y - x^2 y$

C5. Page 56: Eq. (3.46) should be $f_2(x, y) = \beta - \alpha y - x^2 y$

Chapter 4

C6. Page 83: Eq. (4.53) should be $\mathbf{A} = \begin{pmatrix} r_S - 2\frac{r_S K_E S_e}{E_e K_S} & \frac{r_S K_E S_e^2}{E_e^2 K_S} \\ \frac{BP}{S_e^2} & r_E - 2\frac{r_E E_e}{K_E} \end{pmatrix}$

C7. Page 85: Eq. (4.64) should be

$$\begin{pmatrix} \frac{\partial \tilde{C}_x}{\partial t} \\ \frac{\partial \tilde{C}_s}{\partial t} \end{pmatrix} = \begin{pmatrix} \frac{-1.75 + 0.35 C_{se}}{5.0 + C_{se}} & \frac{3.5 C_{xe}}{(5.0 + C_{se})^2} \\ -\frac{1.077 C_{se}}{5.0 + C_{se}} & \frac{-0.35\,(5.0 + C_{se})\,(5.0 + C_{se}) - 5.38 C_{xe}}{(5.0 + C_{se})^2} \end{pmatrix} \begin{pmatrix} \tilde{C}_x \\ \tilde{C}_s \end{pmatrix}$$

C8. Page 85: Eq. (4.65) should be

$$\mathbf{A} = \begin{pmatrix} \dfrac{-1.75 + 0.35C_{se}}{5.0 + C_{se}} & \dfrac{3.5C_{xe}}{(5.0 + C_{se})^2} \\ -\dfrac{1.077C_{se}}{5.0 + C_{se}} & \dfrac{-0.35\,(5.0 + C_{se})\,(5.0 + C_{se}) - 5.38C_{xe}}{(5.0 + C_{se})^2} \end{pmatrix} = \begin{pmatrix} 0.31 & 0 \\ -1.02 & -0.35 \end{pmatrix}$$

C9. Page 85: Eq. (4.66) should be

$$\mathbf{A} = \begin{pmatrix} 0 & 1.82 \\ -0.54 & -3.15 \end{pmatrix}$$

C10. Page 86: Eq. (4.69) should be

$$\frac{d\tilde{x}}{dt} = \left(\frac{-\alpha + \beta^2}{\alpha + \beta^2}\right)\tilde{x} + \left(\alpha + \beta^2\right)\tilde{y}$$

$$\frac{d\tilde{y}}{dt} = \left(-\frac{2\beta^2}{\alpha + \beta^2}\right)\tilde{x} - \left(\alpha + \beta^2\right)\tilde{y}$$

C11. Page 86: Eq. (4.70) should be

$$\mathbf{A} = \begin{bmatrix} \dfrac{-\alpha + \beta^2}{\alpha + \beta^2} & \alpha + \beta^2 \\ -\dfrac{2\beta^2}{\alpha + \beta^2} & -\alpha - \beta^2 \end{bmatrix}$$

C12. Page 86: Eq. (4.71) should be

$$\mathbf{A} = \begin{bmatrix} 0.64 & 0.44 \\ -1.64 & -0.44 \end{bmatrix}$$

C13. Page 89: The second equation should be

$$\frac{dy}{dt} = -y\left(\beta - \gamma_2 x\right)$$

Chapter 5

C14. Page 102: Eq. (5.42) should be

$$\lim_{t\to\infty} f(t) = \lim_{s\to 0} s\bar{f}(s)$$

C15. Page 103: Eq. (5.45) should be

$$\lim_{t\to 0} f(t) = \lim_{s\to\infty} s\bar{f}(s)$$

C16. Page 108: Eq. (5.79) should be

$$\frac{d\tilde{C}_x}{dt} = 1.82\tilde{C}_s$$
$$\frac{d\tilde{C}_s}{dt} = -0.54\tilde{C}_x - 3.15\tilde{C}_s$$

C17. Page 109: Eq. (5.80) should be

$$s\bar{C}_x - \tilde{C}_x(0) = 1.82\bar{C}_s$$
$$s\bar{C}_s - \tilde{C}_s(0) = -0.54\bar{C}_x - 3.15\bar{C}_s$$

C18. Page 109: Eq. (5.81) should be

$$s\bar{C}_x = 1.82\bar{C}_s$$
$$s\bar{C}_s - 1.0 = -0.54\bar{C}_x - 3.15\bar{C}_s$$

C19. Page 109: Eq. (5.82) should be

$$s\bar{C}_x - 1.82\bar{C}_s = 0$$
$$0.54\bar{C}_x + (s+3.15)\bar{C}_s = 1.0$$

C20. Page 109: Eq. (5.83) should be

$$\bar{C}_x = \frac{\begin{vmatrix} 0 & -1.82 \\ 1.0 & s+3.15 \end{vmatrix}}{\begin{vmatrix} s & -1.82 \\ 0.54 & s+3.15 \end{vmatrix}}$$

C21. Page 109: Eq. (5.84) should be

$$\bar{C}_s = \frac{\begin{vmatrix} s & 0 \\ 0.54 & 1.0 \end{vmatrix}}{\begin{vmatrix} s & -1.82 \\ 0.54 & s+3.15 \end{vmatrix}}$$

C22. Page 109: Eq. (5.85) should be

$$\bar{C}_x = \frac{1.82}{(s+0.35)(s+2.80)}$$

C23. Page 113: Problem 5.5 should be

$$\frac{d\tilde{C}_x}{dt} = 2.0\tilde{C}_s$$
$$\frac{d\tilde{C}_s}{dt} = -0.40\tilde{C}_x - 3.0\tilde{C}_s$$

C24. Page 114: Problem 5.6 should be

$$\frac{d\tilde{C}_x}{dt} = 2.5\tilde{C}_s$$
$$\frac{d\tilde{C}_s}{dt} = -0.30\tilde{C}_x - 4.0\tilde{C}_s$$

Chapter 6

C25. Page 134: Eq. (6.89) should be

$$\frac{d\tilde{C}_x}{dt} = 1.82\tilde{C}_s$$
$$\frac{d\tilde{C}_s}{dt} = -0.54\tilde{C}_x - 3.15\tilde{C}_s$$

C26. Page 134: Eq. (6.90) should be

$$\bar{C}_x = \frac{1.82}{(s+0.35)(s+2.80)}$$

C27. Page 135: Eq. (6.91) should be

$$\bar{C}_s = \frac{s}{(s+0.35)(s+2.80)}$$

C28. Page 135: Eq (6.92) should be

$$\rho_1(t) = \lim_{s\to a_1}\left[(s-a_1)\frac{P(s)}{Q(s)}\right]e^{a_1 t}$$

$$\rho_1(t) = \lim_{s\to -0.35}\left[(s+0.35)\frac{1.82}{(s+0.35)(s+2.80)}\right]e^{-\frac{1}{3}t}$$

$$\rho_1(t) = \lim_{s\to -0.35}\left[\frac{1.82}{s+2.80}\right]e^{-0.35t}$$

$$\rho_1(t) = 0.74e^{-0.35t}$$

C29. Page 135: Eq (6.93) should be

$$\rho_2(t) = \lim_{s\to a_2}\left[(s-a_2)\frac{P(s)}{Q(s)}\right]e^{a_2 t}$$

$$\rho_2(t) = \lim_{s\to -2.80}\left[(s+2.80)\frac{1.82}{(s+0.35)(s+2.80)}\right]e^{-2.80t}$$

$$\rho_2(t) = \lim_{s\to -2.80}\left[\frac{1.82}{s+0.35}\right]e^{-2.80t}$$

$$\rho_2(t) = -0.74e^{-2.80t}$$

C30. Page 135: Eq (6.95) should be

$$\tilde{C}_x(t) = 0.74e^{-0.35t} - 0.74e^{-2.80t}$$

Chapter 7

C31. Page 156: Eq (7.26) should be

$$\frac{d\tilde{m}_I}{dt} = -\left(k_1 + \frac{v_{\max}}{(k_M + m_{Is})^2}\right)\tilde{m}_I + k_2\tilde{m}_{II} + \tilde{u}(t)$$

C32. Page 156: Eq (7.28) should be

$$k_{E1} = \frac{v_{\max}}{(k_M + m_{Is})^2}$$

Chapter 8

C33. Page 165: In the line below Eq. (8.8) replace $\tau = a_2/a_0$ by $\tau^2 = a_2/a_0$.

Chapter 11

C34. Page 248: Third line: the expression for s_4 is $s_4 = -1.595 + 0.8490i$

C35. Page 249: The third line after equation (11.13): Replace $s^3 + 5s^2 + 6s + k = 0$ by $s^3 + 5s^2 + 6s + K_c = 0$

C36. Page 253: Example 11.6: Step 1 in ***Solution***, the expression for $G_{OL}(s)$ is

$$G_{OL}(s) = G_p(s)G_f(s)G_c(s)G_m(s) = 30e^{-0.4s} / (4s+1)$$

Chapter 12

C37. Page 271: Eq. (12.6) should be

$$G_{RC} = \frac{4e^{-0.194s}}{1.547s + 1}$$

C38. Page 273: The last line of Table 12.3 is PID:

$$0.6K_u \qquad P_u / 2 \qquad P_u / 8$$

C39. Page 280: The last line is $\tau_D = 50.826$ instead of "$\tau_D = 225.89$"

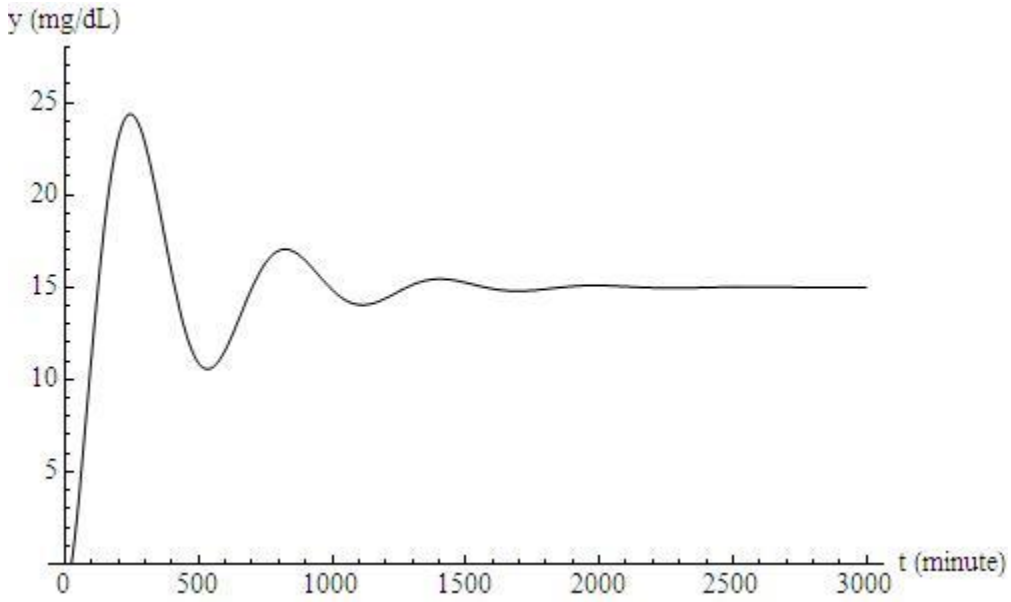
C40. Page 281: Eq. (12.42) should be

$$G_{SP}(s) = \frac{1.16291s^2 + 0.023s + 0.00011}{146s^3e^{27s} + s^2(1.16 + e^{27s}) + 0.0229s + 0.000112}$$

C41. Page 281: Eq. (12.44) should be

$$y(t) = 15\left[\begin{array}{l} 0.325e^{-0.00264t}\sin(0.0108t) - 1.196e^{-0.00264t}\cos(0.0108t) \\ +0.251e^{-0.06t} - 0.054e^{-0.0076t} + 1 \end{array}\right]$$

C42. Page 281: Fig 12.5 should be [the figure is attached as "ch12fg12_5.eps"]



C43. Page 290: Problem 12.6: Part a) "Derive a PI controller" instead of "Derive a PID controller"

C44. Page 291: Problem 12.9: The FOPDT model should be

$$\tilde{G}_p = -\frac{1.0e^{-27.7s}}{97.2s+1}$$

instead of

$$\tilde{G}_p = -\frac{1.0e^{27.7s}}{97.2s+1}$$

Chapter 13

C45. Page 305, sixth line: Use "$\tau_D = 50.826$" instead of "$\tau_D = 225.89$"

C46. Page 305, line 7: Replace the equation

$$\bar{y}(s) = \frac{2541.26s^2 + 11.25s + 0.055}{146s^4 + 170.42s^3 + 0.75s^2 + 0.0037s} e^{-27s}$$

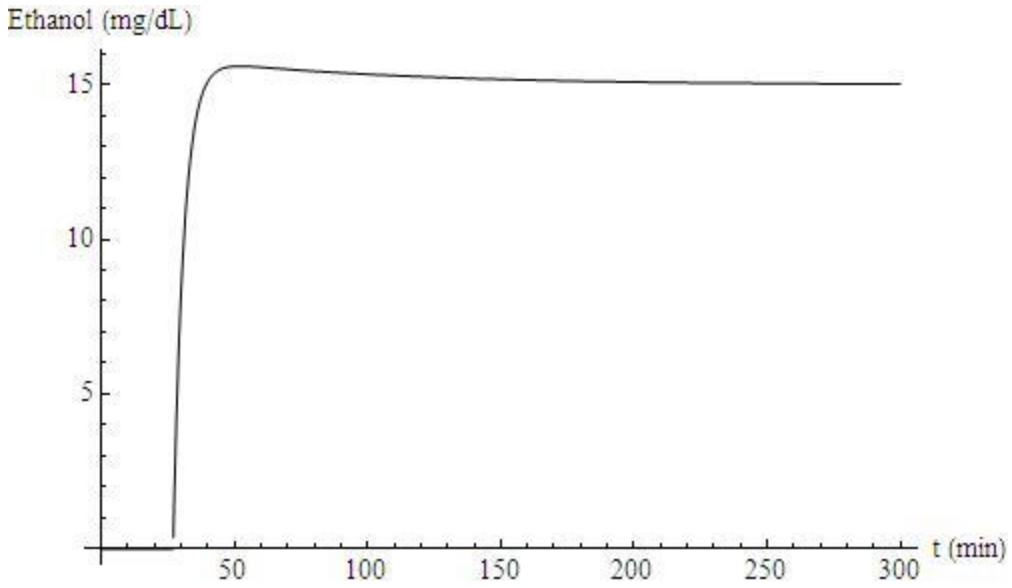
with

$$\bar{y}(s) = \frac{571.79s^2 + 11.25s + 0.055}{146s^4 + 39.12s^3 + 0.75s^2 + 0.0037s} e^{-27s}$$

C47. Page 305: Eq. (13.18) should be

$$y(t) = \left[15 - 15.86e^{-0.25t} + 1.395e^{-0.0113t} - 0.5342e^{-0.009t}\right]\psi(t_1)$$

C48. Page 305: Fig. 13.9 should be [the figure is attached as "ch13fg12_9.eps"]



Chapter 14

C50. Page 315: Figure 14.5: The box "$G_{c1}(s)$" should be "$G_c(s)$"

C51. Page 316: Eq. (14.11) should be

$$G_{SP-C}(s) = \frac{G_{p1}(s)G_c(s)G_{p2}(s)}{1+G_{p1}(s)G_c(s)G_{p2}(s)G_{m1}(s)}$$

C52. Page 316: Eq. (14.12) should be

$$G_{load1-C}(s) = \frac{G_{d1}(s)}{1+G_{p1}(s)G_c(s)G_{p2}(s)G_{m1}(s)}$$

C53. Page 316: Eq. (14.13) should be

$$G_{load2-C}(s) = \frac{G_{p1}(s)G_{d2}(s)}{1+G_{p1}(s)G_c(s)G_{p2}(s)G_{m1}(s)}$$