The following is a list of known errors in the text. If you come across any others, please send them to me at `tmk5@calvin.edu`.

- p. 4: the highlighted equation on the bottom of the page should read,

$$2x_1 - x_2 = -2, \quad -4x_1 + 2x_2 = 4.$$

- p. 7: in Definition 1.4 (RREF) the listed items should read,
  (a) all nonzero rows are above any zero row,
  (b) the first nonzero entry in a row (the leading entry) is a one,
  (c) every other entry in a column with a leading one is a zero, and
  (d) the leading entry in a given row must be to the right of the leading entry in the row above.

- p. 12: Exercise 1.1.6 should read, "If the coefficient matrix satisfies $\boldsymbol{A} \in \mathcal{M}_{9\times 6}(\mathbb{R})$, and if the RREF of $\boldsymbol{A}$ has three zero rows, is the solution to the consistent linear system $\boldsymbol{Ax} = \boldsymbol{b}$ unique? Why or why not?"

- p. 12: Exercise 1.1.10(b) it should read, "If a consistent system has a free variable, then there will be an infinite number of solutions."

- p. 19: the phrase "even though matrix multiplication is not necessarily commutative, it is associative" should read "even though matrix multiplication is not necessarily commutative, it is distributive across addition"

- p. 27: 4 lines above Example 1.29 strike the line "Note that $\boldsymbol{x}_{\mathrm{p}}$ is the last column of the RREF of the augmented matrix $(\boldsymbol{A}|\boldsymbol{b})$."

- p. 28: strike the last sentence in Example 1.29, "Note that the chosen particular solution is the last column of the RREF of $(\boldsymbol{A}|\boldsymbol{b})$."

- p. 33: the right-hand side of the $\rightsquigarrow$ in equation (1.6.1) should read $2\boldsymbol{a}_1 + 3\boldsymbol{a}_2 - \boldsymbol{a}_3 = \boldsymbol{0}$

- p. 34: the last equation in the second-to-last displayed line should read,

$$\boldsymbol{x} = t\begin{pmatrix} -2 \\ 1 \\ 1 \end{pmatrix}, \quad t \in \mathbb{R}.$$

- p. 35: the last equation in the third displayed line should read,

$$\boldsymbol{x} = t\begin{pmatrix} -2 \\ 1 \\ 1 \\ 0 \end{pmatrix}, \quad t \in \mathbb{R}.$$

- p. 39: in Exercise 1.6.7 "YES" should read "NO"

- p. 46: in Exercise 1.7.8(a) strike the word "and"

- p. 55: in Theorem 1.68 add to the enumerated list, "(e) $\boldsymbol{b} \in \mathrm{Col}(\boldsymbol{A})$"

- p. 57: in Theorem 1.73 it should be assumed that $m \geq n$

- p. 58: 5 lines above Theorem 1.75 strike the sentence, "Going back to the definition of the determinant, we see that (a) is equivalent to $\det(\boldsymbol{A}) \neq 0$."

- p. 58: in Theorem 1.75 strike condition (h), $\det(\boldsymbol{A}) \neq 0$

- p. 58: in Theorem 1.76 strike condition (a), $\det(\boldsymbol{A}) = 0$
- p. 68: in Example 1.86 the displayed line should read,

$$|z| = 4, \quad \tan\theta = \sqrt{3} \rightsquigarrow \theta = \frac{\pi}{3},$$

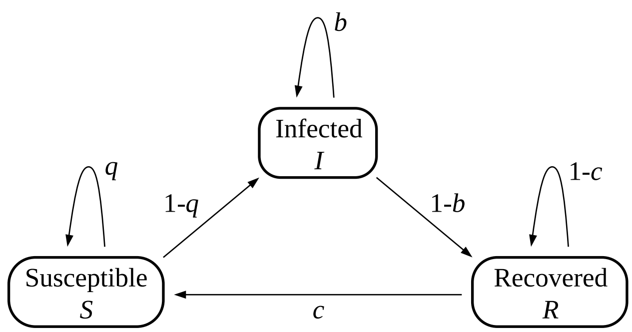
- p. 69: the last displayed equation in Example 1.88 should read

$$\boldsymbol{x} = \begin{pmatrix} 9 + \mathrm{i}9 \\ -3 \end{pmatrix} = \begin{pmatrix} 9 \\ -3 \end{pmatrix} + \mathrm{i}\begin{pmatrix} 9 \\ 0 \end{pmatrix}.$$

- p. 74: The first full sentence on the top of the page should read, "In this example, $\lambda = 1$ is such that $\mathrm{m_a}(1) = 2$ (a double eigenvalue), and $\lambda = 3$ is such that $\mathrm{m_a}(3) = 4$ (a quartic eigenvalue)."
- p. 86: the matrix $\boldsymbol{C}_3$ should read

$$\boldsymbol{C}_3 = \begin{pmatrix} 1 & 0 & 0 \\ -a_2 & 1 & 0 \\ -a_1 + a_2^2 & -a_2 & 1 \end{pmatrix}$$

- p. 90: accompanying equation (1.13.7) there should be the below figure:



- p. 97: Group Project **1.2**(c) should read "S is more likely to click on the link from B to A (rather than on a link to some other page C from B) if there are not many links from B to other pages."
- p. 98: the phrase "E and F are each linked to be three other pages" should read "E and F are each linked to by three other pages"
- p. 98: the phrase "weighted sum of the number of number of links" should read "weighted sum of the number of links"
- p. 104: in Exercise 2.1.3 the phrase "the temperature of the body" should read "the rate of change of the temperature of the body"
- p. 106: in the caption for Figure 2.3 the references to "blue" and "green" should be ignored
- p. 112: in the second displayed line the expression $c_1x_1' + x_2x_2'$ should read $c_1x_1' + c_2x_2'$
- p. 112: at the end of the first paragraph strike the sentence "A solution to a homogeneous problem is unique only up to scalar multiplication."
- p. 113: in the first sentence of the last paragraph "(3.3.1)" should read "(2.3.1)"

- p. 122: the second displayed equation should read

$$(4a_0 - 8)\,\mathrm{e}^{3t} = 0.$$

the third displayed equation should read

$$4a_0 - 8 = 0 \quad \rightsquigarrow \quad a_0 = 2.$$

the fourth displayed equation should read

$$x_{\mathrm{p}}(t) = 2\mathrm{e}^{3t},$$

and the fifth displayed equation should read

$$x(t) = c_1\mathrm{e}^{-t} + 2\mathrm{e}^{3t}.$$

- p. 124: the solution at the end of Example 2.19 should read

$$x(t) = c_1\mathrm{e}^{-7t} + 3t\mathrm{e}^{-7t}$$

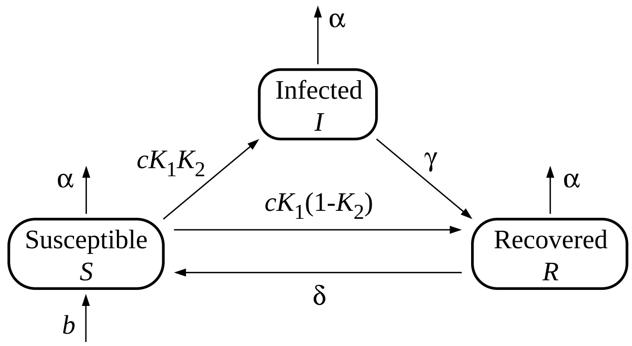
- p. 125: the phrase "we see one guess associated with $t\sin(2t)$ and another guess associated with the polynomial t^2. For the guess associated with (d), we needed to" should read "we see one guess associated with $t^3\mathrm{e}^{5t}$ and another guess associated with the polynomial t^2. Moreover, we needed to"
- p. 137: in the second displayed equation $g(G, I)$ should read $f(G, I)$
- p. 140: in the caption associated with Figure 3.4 the final phrase in the second sentence should read "denoted by letters."
- p. 172: in Exercise 3.5.2 the solution should read,

$$\boldsymbol{x}(t) = c_1\mathrm{e}^{-5t}\begin{pmatrix}\cos(2t) - 3\sin(2t)\\ -4\cos(2t) + \sin(2t)\end{pmatrix} + c_2\mathrm{e}^{-5t}\begin{pmatrix}\sin(2t) + 3\cos(2t)\\ -4\sin(2t) - \cos(2t)\end{pmatrix}.$$

- p. 177: in the first and second displayed lines the $(2, 1)$ entry of $\mathbf{\Phi}(t)^{-1}$ should read $2\mathrm{e}^{-5t}$
- p. 184: in the first displayed line the $(1, 2)$ and $(2, 2)$ entry of $\mathbf{\Phi}(t)$ should each be multiplied by -1
- p. 189: in the caption for Fig. 3.15 the phrase "and leaves tissue loss" should read ", and is also removed via tissue loss"
- p. 189: in the first system of displayed equations the term $-r_{20}x_2$ in the equation for x_2' should read $-(r_{20} + r_{21})x_2$
- p. 192: the description for infected should read, "those who are infected with the disease and ill because of it"
- p. 192: equation (3.7.3) should read,

$$\begin{aligned} S' &= -(cK_1 + \alpha)S + \delta R + b(a)\\ I' &= cK_1K_2S - (\alpha + \gamma)I\\ R' &= cK_1(1 - K_2)S + \gamma I - (\alpha + \delta)R, \end{aligned}$$

and accompanying equation (3.7.3) there should be the figure:



- p. 193: The sentence surrounding equation (3.7.4) should read, "The function $b(a)$ influences the rate at which the total population changes,

$$N' = -\alpha N + b(a), \qquad (3.7.4)$$

(see Exercise 3.7.3)."

- p. 193: the matrix $\boldsymbol{A}$ in the middle of the page should read,

$$\boldsymbol{A} = \begin{pmatrix} -(cK_1+\alpha) & 0 & \delta \\ cK_1K_2 & -(\alpha+\gamma) & 0 \\ cK_1(1-K_2) & \gamma & -(\alpha+\delta) \end{pmatrix}.$$

- p. 194: Regarding the urban population, the highlighted matrix $\boldsymbol{A}$ on the top of the page should read,

$$\boldsymbol{A} = \begin{pmatrix} -41/80 & 0 & 9/10 \\ 1/4 & -961/80 & 0 \\ 1/4 & 12 & -73/80 \end{pmatrix}.$$

The eigenvalues and associated eigenvectors are,

$$\lambda_1 \sim -11.99,\ \boldsymbol{v}_1 \sim \begin{pmatrix} 1.00 \\ 11.75 \\ -12.75 \end{pmatrix}; \quad \lambda_2 \sim -1.43,\ \boldsymbol{v}_2 \sim \begin{pmatrix} 1.00 \\ 0.02 \\ -1.02 \end{pmatrix}$$

and

$$\lambda_3 = -\frac{1}{80},\ \boldsymbol{v}_3 = \begin{pmatrix} 1 \\ 1/48 \\ 5/9 \end{pmatrix}.$$

The general solution is,

$$\boldsymbol{x}(a) = c_1 \mathrm{e}^{\lambda_1 a}\boldsymbol{v}_1 + c_2 \mathrm{e}^{\lambda_2 a}\boldsymbol{v}_2 + c_3 \mathrm{e}^{\lambda_3 a}\boldsymbol{v}_3.$$

Since

$$a > 7 \quad \rightsquigarrow \quad \mathrm{e}^{\lambda_1 a}, \mathrm{e}^{\lambda_2 a} < 10^{-4},$$

for $a > 7$ the solution is approximately,

$$\boldsymbol{x}(a) \sim c_3 \mathrm{e}^{-a/80} \begin{pmatrix} 1 \\ 1/48 \\ 5/9 \end{pmatrix} = \frac{227}{144} c_3 \mathrm{e}^{-a/80} \begin{pmatrix} 144/227 \\ 3/227 \\ 80/227 \end{pmatrix}.$$

For an "old" urban population, 63.4% of the people will be susceptible, 1.3% will be infected and ill, and 35.3% will be recovered or immune.

- p. 194: Regarding the rural population, the highlighted matrix $\boldsymbol{A}$ on the bottom of the page should read,

$$\boldsymbol{A} = \begin{pmatrix} -81/80 & 0 & 1/20 \\ 1/2 & -961/80 & 0 \\ 1/2 & 12 & -1/16 \end{pmatrix}.$$

The eigenvalues and associated eigenvectors are,

$$\lambda_1 \sim -12.01,\ \boldsymbol{v}_1 \sim \begin{pmatrix} 1.00 \\ 218.95 \\ -219.95 \end{pmatrix};\quad \lambda_2 \sim -1.06,\ \boldsymbol{v}_2 \sim \begin{pmatrix} 1.00 \\ 0.05 \\ -1.05 \end{pmatrix}$$

and

$$\lambda_3 = -\frac{1}{80},\ \boldsymbol{v}_3 = \begin{pmatrix} 1 \\ 1/24 \\ 20 \end{pmatrix}.$$

The general solution is,

$$\boldsymbol{x}(a) = c_1 \mathrm{e}^{\lambda_1 a}\boldsymbol{v}_1 + c_2 \mathrm{e}^{\lambda_2 a}\boldsymbol{v}_2 + c_3 \mathrm{e}^{\lambda_3 a}\boldsymbol{v}_3.$$

Since

$$a > 9 \quad \rightsquigarrow \quad \mathrm{e}^{\lambda_1 a}, \mathrm{e}^{\lambda_2 a} < 10^{-4},$$

for $a > 9$ the solution is approximately,

$$\boldsymbol{x}(a) \sim c_3 \mathrm{e}^{-a/80} \begin{pmatrix} 1 \\ 1/24 \\ 20 \end{pmatrix} = \frac{505}{24} c_3 \mathrm{e}^{-a/80} \begin{pmatrix} 24/505 \\ 1/505 \\ 96/101 \end{pmatrix}.$$

For an “old” rural population, 4.8% of the people will be susceptible, 0.2% will be infected and ill, and 95.0% will be recovered or immune.

- p. 196: in Exercise 3.7.3 the highlighted equation should read,

$$N' = -\alpha N + b(a).$$

- p. 200: Project 3.5 should now read:
3.5. Consider the SIR model of (3.7.3). Suppose the total number of births in a particular city is 10,000. Thereafter, suppose that there is an age-dependent influx of people into this city, where the rate of influx is modeled by,

$$b(a) = 1100 \mathrm{e}^{-11a/80}.$$

Suppose for a particular bacterial infection the parameters are,

$$\alpha = \frac{1}{80},\ \gamma = 26,\ c = 1,\ K_1 = \frac{3}{200},\ K_2 = \frac{2}{10},\ \delta = \frac{35}{100}.$$

  (a) What is the total number of people ages 0 to 80 who enter the city from outside?
  (b) For a group of 5-year-old children, what percentage of the population is susceptible? Infected and ill? Recovered or immune?
  (c) For a group of 20-year-old adults, what percentage of the population is susceptible? Infected and ill? Recovered or immune?
  (d) For a group of 50-year-old adults, what percentage of the population is susceptible? Infected and ill? Recovered or immune?
  (e) Is there an age for which the percentages in each group are essentially fixed thereafter (use an error bound of 10^{-3})? If so, what is it? Is it reasonable to expect that this age can be reached?

- p. 202: the characteristic polynomial in equation (4.1.2) should read

$$p_{\boldsymbol{A}}(\lambda) = (-1)^n \left(\lambda^n + a_{n-1}\lambda^{n-1} + \cdots + a_1\lambda + a_0\right)$$

- p. 207: in Theorem 4.5 the last displayed equation should read

$$y(t) = \left(c_1 + c_2 t + \cdots + c_k t^{k-1}\right) \mathrm{e}^{at} \cos(bt) + \left(c_{k+1} + c_{k+2} t + \cdots + c_{2k} t^{k-1}\right) \mathrm{e}^{at} \sin(bt),$$

- p. 208: in Exercise 4.1.2(b) the characteristic polynomial should read

$$p_{\boldsymbol{A}}(\lambda) = -\left(\lambda^3 + a_2\lambda^2 + a_1\lambda + a_0\right)$$

- p. 214: the third displayed equation in Example 4.15 should read,

$$-a_0 + 8a_1 = 4,\ -8a_0 - a_1 = 0 \quad \rightsquigarrow \quad \begin{pmatrix} -1 & 8 \\ -8 & -1 \end{pmatrix} \boldsymbol{a} = \begin{pmatrix} 4 \\ 0 \end{pmatrix}.$$

- p. 218: The second paragraph should read, "The homogeneous problem is

  $$y'' + 2by' + \omega_0^2 y = 0.$$

  The associated characteristic polynomial is

  $$p(\lambda) = \lambda^2 + 2b\lambda + \omega_0^2,$$

  which has the zeros,

  $$\lambda = \lambda_{\pm} = -b \pm \sqrt{b^2 - \omega_0^2}.$$

  The solution behavior depends on the relationship between b and ω_0. A summary cartoon is provided in Figure 4.1"

- p. 228: in the displayed line above equation (4.3.8) ω_n^2 should read ω_{n}^2.
- p. 234: in (d) the first sentence should read, "Assume there is no damping, i.e., $b = 0$."
- p. 235: the first displayed line in part (d) should read,

$$a, b, d < 0, \quad c > 0.$$

- p. 238: in Example 5.2 the definition for $f(t)$ should have $5 \le t$ instead of $5 < t$
- p. 240: in Definition 5.5 the phrase "M, $b > 0$" should read "C, $b > 0$"
- p. 270: the first displayed line in part (d) should read,

$$a, b, d < 0, \quad c > 0.$$